The value of value addition in coffee production in Uganda

by

Minyoung Jun

B.S., Handong University, 2007
M.S., Kyung Hee University, 2015

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Agricultural Economics
College of Agriculture

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Manhattan, Kansas

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Abstract

Coffee is one of Uganda's most prominent foreign exchange earners and major agricultural exports. The question of how much of the final market price of coffee farmers receive has attracted significant attention by policymakers and researchers. Previous researchers have shown that farmers can increase their share of the final market price for their commodities if they undertake value addition to their commodities. As an export crop, the final price of coffee is complex and therefore difficult to assess farmers' share of it. Thus, it is unclear whether value addition enhancements for coffee improve farmers' economic performance in Uganda. The primary objective of this dissertation is to assess the extent to which value addition in coffee improves Uganda coffee farmers' profitability. Because fresh coffee cherries can deteriorate in quality if not stored properly, and because proper storage of fresh coffee cherries can be difficult, farmers may be motivated to add value to the fresh cherries as risk management strategies instead of securing higher prices for value added products. Either way, the process of adding value is expected to enhance farmers' profitability.

Robusta and Arabica are the two main coffee varieties in Uganda. While some farmers produce only a single variety of coffee, others produce both varieties despite their distinct agronomic requirements. This dissertation explores value addition enhancements undertaken by three types of farmers: (1) those producing only Robusta coffee; (2) those producing only Arabica coffee; and (3) and those producing both varieties simultaneously. Value addition in coffee in Uganda is performed by drying coffee cherries and/or hulling coffee beans. The study then explores the effect of different farmers' characteristics on their likelihood of undertaking specific value addition activities.

Using 2013/14 Uganda National Panel Survey (UNPS) for the analyses, the study's statistics show that the average coffee prices per kilogram of Robusta fresh cherries, dried cherries, or hulled coffee beans are UGX 1,600; UGX 3,370; and UGX 3,790, respectively. For Arabica, the average prices for fresh cherries, dried cherries and beans were estimated at UGX 1,960, UGX 3,110 and UGX 5,220, respectively.

The results of this study show that certain characteristics of farmers make them more likely to undertake value addition. For example, the odds of value addition for Robusta growers was by 5.6 times higher than the odds of value addition for non-Robusta farmers ($p < 0.000$), *ceteris paribus*. The marginal probability effect of growing Robusta was estimated as 41% at the means of all other variables in the model. An increase in one hectare of land increased the odds ratio of value addition by 6.9 times higher ($p < 0.000$). Similarly, an additional year of schooling of the household head increased the odds of adding value by 1.13 times ($p < 0.000$).

This study also confirmed that Arabica is not the dominant coffee variety in Uganda even though it commands a higher price on the market. Growing conditions in Uganda limit farmers' production of Arabica coffee. This study shows that Robusta growers tend to add value to their products at a higher rate than Arabica growers, and that they subsequently secure a higher percentage of increase in their prices as a result of their value addition activities. The percentage change of price from fresh Robusta cherries to dried Robusta cherries is 111%. On the other hand, the percentage change from fresh Arabica cherries to dried Arabica cherries is only 59%. The percentage changes of price from dried Robusta and Arabica cherries to hulled Robusta and Arabica green beans are 12% and 68%, respectively. Thus, the value addition benefits of selling hulled dried green beans were significantly much higher for Arabica than for Robusta while the benefit of drying fresh cherries seemed better for Robusta. This would suggest that Arabica producers are likely to benefit more from their value adding activities by completing the value addition process, i.e., drying and hulling, instead of stopping at drying, if the option is available to them and is economically feasible.

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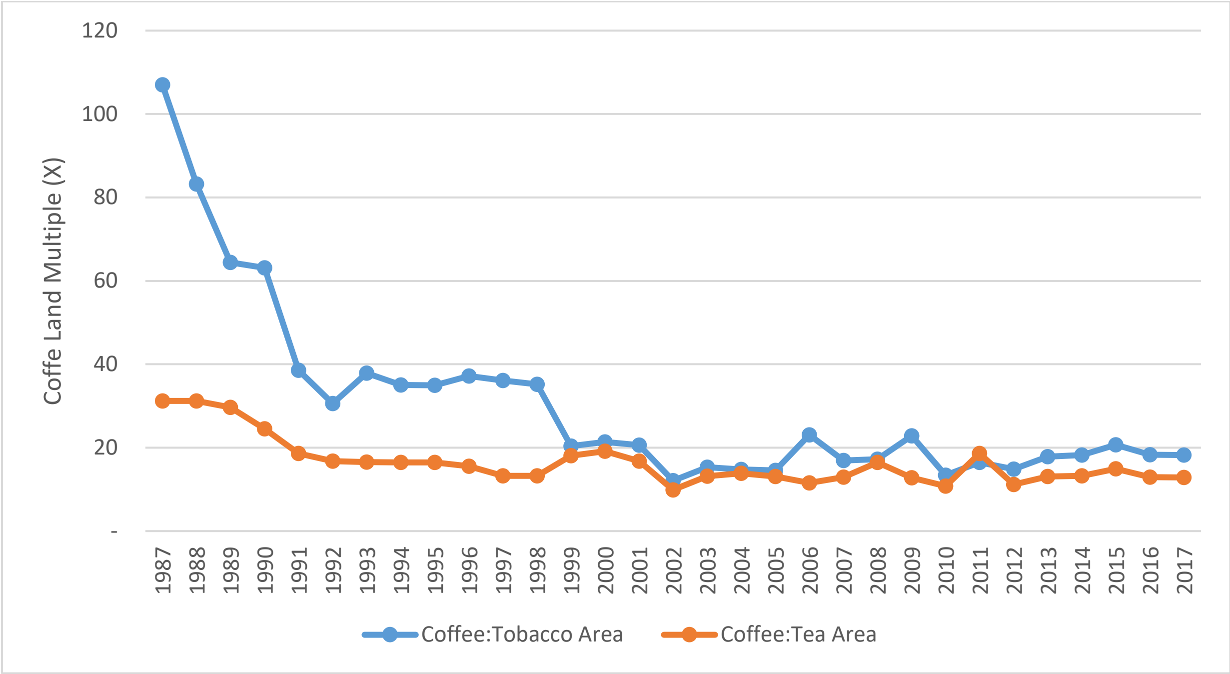
Chapter 1 - Background

1.1 Agriculture and the Ugandan Economy

Agriculture is a key sector in Uganda's economy. Overall, agriculture contributed about 22% of Uganda's US$ 30 billion Gross Domestic Product (GDP) in 2018 (Uganda Bureau of Statistics [UBOS] 2019), and it accounted for over one third of Uganda's total export in 2018 (Bank of Uganda [BOU] 2019). In terms of land use, although coffee, tea, and tobacco are Uganda's cash crops, they represent a relatively small share of agricultural land area compared to food crops. However, those cash crops are major income earners for a very large portion of Uganda's farming population. For that reason, policymakers and their development agency partners have considered the sustainability of Uganda's cash crops important.

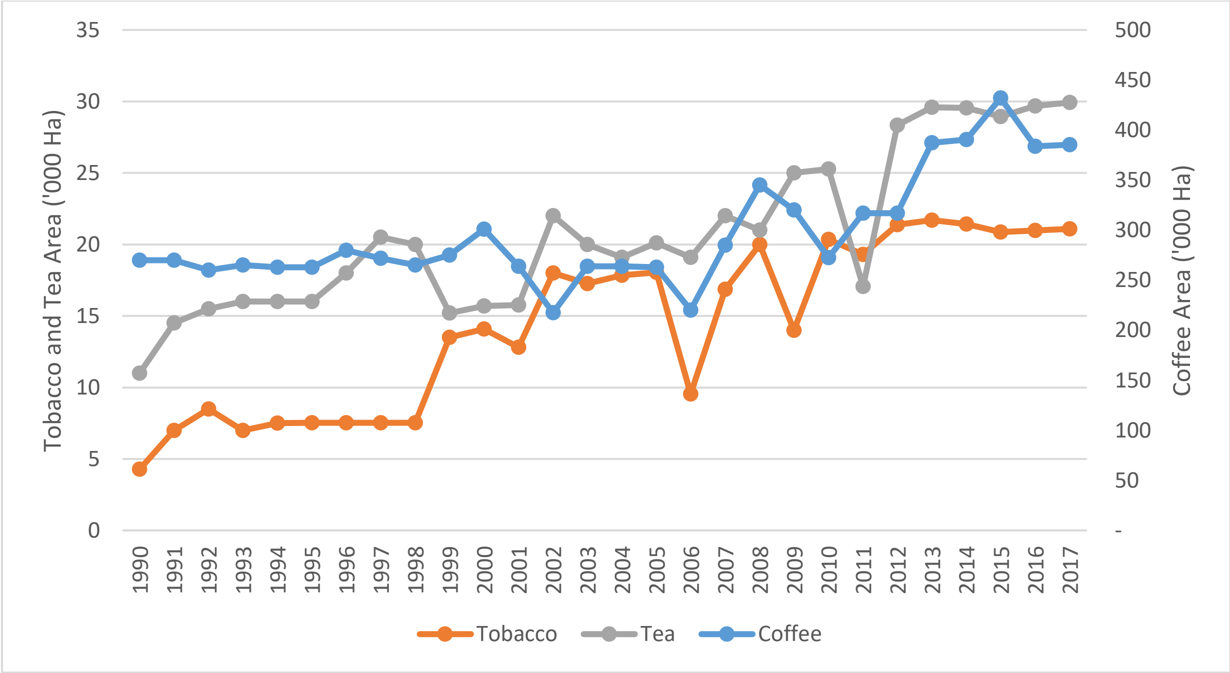
Over the years, coffee has remained the most vital crop to Ugandan farmers' livelihoods. Additionally, of Uganda's cash crops, coffee supplies the greatest contribution to the nation's GDP. The importance of coffee to Uganda is reflected by the amount of land allocated to coffee production compared to tobacco and tea. For example, Figure 1.1 shows the harvested area of coffee compared to those of tobacco and tea between 1987 and 2017, revealing that coffee harvested area was 30.3 times and 16.4 times higher than the harvested area for tobacco and tea in Uganda. Figure 1.1 also shows that this multiplier has been decreasing at an average annual rate of about 5% for tobacco and 2.3% for tea during the period. This may reflect that the harvest area allocated to coffee over the years is not growing as quickly as those allocated for tobacco and tea. Moreover, the growth rate of the harvested area allocated for coffee has stagnated compared to those of tobacco and tea. Figure 1.2 shows that the harvested area for coffee has been increasing at approximately 1.5% per year compared to 5.2% for tobacco and 2.8% for tea between 1990 and 2009.

Figure 1.1: Coffee Harvest Area as a Proportion of Tobacco and Tea Harvested Area



Source: United Nations, Food and Agricultural Organization, 2017 (http://www.fao.org/faostat/en/#-data/QC)

Figure 1.2: Harvested Area of Coffee, Tea, and Tobacco in Uganda (1990-2017)



Source: United Nations, Food and Agricultural Organization, 2017(http://www.fao.org/faostat/en/#-data/QC)

Coffee accounts for 20% of the total export revenue of Uganda (Bank of Uganda 2018). It is produced by more than 1.5 million households, and it is the primary income source for about half a million households (United Nations 2017). The World Bank reported that coffee is a significant and reliable income source for the remaining one million households in Uganda, although it is not their primary income source (World Bank 2011). While coffee yield in Uganda has been relatively stagnant over the years, tea and tobacco yields have been growing. For example, between 1961 and 1987, the average yield of coffee in Uganda was 0.64 MT/ha, a figure nearly identical to the average yield between 1988 and 2017. On the other hand, the average yield of tea increased from about 0.96 MT/ha to 1.60 MT/ha, while the average yield of tobacco increased from 0.54 MT/ha to 1.37 MT/ha between 1988 and 2017.

The yields of major coffee producers, unlike Uganda, have also been increasing. Brazil, the leading coffee producer, increased its average yield of coffee from 0.52 MT/ha to 0.94 MT/ha between 1988 and 2017, and increase of nearly 81%. Similarly, Vietnam's average yield nearly quadrupled, with an increase from 0.49 MT/ha to 1.91 MT/ha over the same period. Despite coffee's relative size advantage in Uganda, the relative coffee yield stagnation in relation to other cash crops could cause diversion of land away from coffee to these crops if it is not addressed. Figure 1.2 above demonstrates the higher growth rates of allocated land to tobacco and tea, supporting the potential risk to coffee production presented by the coffee's yield disadvantage. Considering the large number of households dependent on coffee, the government of Uganda has attempted to develop incentives to address the yield issue and reduce the risk of losing land from coffee to other cash crops. For example, the government has been providing improved high-yield coffee seedlings to farmers as a replanting initiative to replace low-yielding aged trees. The National Coffee Policy, which was launched in 2013, involves the distribution of improved seedlings to coffee farmers through the services of retired and inactive members of the Ugandan Peoples Defense Force. The policy plans to supply 300 million seedlings per year between 2017 and 2020. A report published by the United States Department of Agriculture (USDA) in 2019 suggested that the program is already attaining some success. The trees planted at the beginning of the program have contributed to increased crop production. Furthermore, the Ugandan government's objective of reaching 5.4 million bags by 2020 seems achievable, as the 2018/2019 marketing year production forecast approximately 4.8 million bags (Gitonga 2018). However, achieving production of 20 million bags by 2030 would require aggressive changes in production and producer incentives. The government's 2030 objective requires an increase of more than 14 million bags in about 10 years, equivalent to about 20% growth per year from the base year production of 5.4 million bags. This can only be achieved with a combination of yield improvement and new land being allocated to coffee production at a higher rate than is currently being done.

A feasible way to motivate farmers to increase their allocation of land to coffee and invest other resources in coffee is to increase coffee prices to enhance coffee's overall competitiveness. Coffee produced in Uganda is primarily sold in global markets and, like most agricultural commodities, the price of coffee is determined by the supply and demand conditions of the market. Since Uganda's coffee is not very different from other coffees on the commodity market, it is subject to global coffee prices, which affect farmers' profitability.

One way of increasing farmers' profit is for them to undertake some of the value-adding activities that coffee buyers perform. When activities traditionally performed at a downstream node in the supply chain are performed at an upstream node, the upstream firm performing that activity is considered to be adding value to the product (Gray et al. 2004; Amanor-Boadu 2013).

In Uganda’s coffee industry, value-adding activities involve drying coffee cherries and/or hulling these dried cherries prior to sale. Hence, farmers have the opportunity to sell their coffee products in one of three formats: fresh red cherries; dried cherries; and hulled green beans.

Some coffee farmers have begun undertaking value-adding activities in Uganda. Identifying these farmers and assessing their characteristics and performances could provide insight into how the Ugandan government might assist farmers’ value addition initiatives. If supporting such activities does enhance farmers’ incomes in coffee production, the Ugandan government could aid farmers investing in increased land allocation to coffee crops and new seedlings to accelerate production. In turn, this would allow the Ugandan government to achieve the production targets of the National Coffee Policy.

1.2 Research Problem and Research Question

The problem of interest in this research is improving farmers’ share of market price by adding value to their commodities. Common sense dictates that because farmers are saving downstream buyers costs by undertaking value-adding activities downstream players would otherwise have to perform, farmers would extract a certain portion of the value downstream buyers would receive to compensate them for their contributions to the product’s overall value. While the benefits of value addition have been explored in other commodities (Collinson et al. 2003; Johnston and Meyer 2008), value addition has not been adequately assessed as a strategic policy initiative for Uganda’s coffee farmers. Given the challenges facing farmers in terms of domestic competition from other cash crops and international competition from other coffee-producing countries, it is imperative that all strategies to enhance coffee’s value to farmers are explored to ensure the long-term sustainability of farmers’ investments in coffee crops. Understanding the potential benefits of value addition for Uganda’s coffee farmers could also provide insight as to other supports the industry may require. For example, motivating new seedling planting, better agronomic and husbandry initiatives, and the production of larger volumes and higher quality of coffee may enhance Uganda's position in the global coffee industry.

The gap in the literature regarding benefits of value addition to coffee farmers has informed this study's two-part research question:

1. What farm and farmer characteristics support value addition activities?
2. To what extent do value addition activities enhance coffee farmers' realized prices?

There is a general consensus in the literature that value addition increases the share of the final market price obtained by the person undertaking the value addition. For example, Adeyemo et al. (2018) studied the effect of value addition on the productivity of nearly 500 cassava farmers in Nigeria, and they found that while the cost facing these farmers increased, their revenue increased as well. Adeyemo et al. also found that value addition improved the farmers' operating efficiencies. If this holds true in the case of Ugandan coffee farmers, value addition activities may allow farmers to produce more domestically competitive (as compared to other cash crops) coffee crops while potentially making it possible to achieve the National Coffee Policy's targets. Answering these questions also provides an opportunity to develop specific policies for specific farmers and farms to ensure that they get the most out of their value addition initiatives.

1.3 Research Objectives

The overall objective of this research was to assess the farm and farmer characteristics that supported value-added activities undertaken by coffee farmers and determine the extent to which these value-added activities improved farm performance. The specific objectives were as follows:

1. Describe the characteristics of Ugandan coffee farmers and compare the farm and farmer characteristics of those engaging or not engaging in value addition.

2. Evaluate the extent to which value addition influences the performance of Ugandan coffee farmers.
3. Use the results to provide insights for policymakers attempting to ensure the achievement of the National Coffee Policy.

1.4 Outline of Dissertation

The next chapter of the dissertation presents a review of the literature on value addition and the context of coffee production in Uganda. As previously discussed, coffee, which is primarily produced for exportation, is the most important cash crop in Uganda. However, growth rates reflect that other cash crops such as tobacco and tea are being produced at greater rates in allocated land area and yield than coffee in recent years. Through the literature review, the study attempts to better evaluate the global coffee market and agriculture environment of cash crops in Uganda in order to understand this issue with respect to resource allocation and yield. The literature review also explores the concept of value addition and its varied applications in agricultural production, examining the processes of value addition in coffee and providing the foundation for assessing the economic and strategic value of undertaking value addition.

Chapter 3 describes the study area, the data, and the theoretical, conceptual, and empirical models used to achieve the stated objectives. In describing the study area and data, the operational environment and decision framework of Ugandan farmers will be explored to better understand the challenges they present to the analyses. This study develops a theoretical model to describe the environment and decision process of coffee farmers engaging in value addition. The conceptual models encompass descriptions of the statistical and econometric models used for the empirical segments of the research.

The results from the analyses are presented and discussed in Chapter 4. The discussion addresses the study's stated objectives research questions. This section also explains the test results of the hypotheses.

Chapter 5 summarizes the study, identifies the limitations of the study and how they may be overcome by future research initiatives, and provides concluding observations regarding the research and recommendations for policymakers. The insights from these results and their implications for current policies are also discussed. These recommendations have been limited to initiatives that are supported by the research and focused on their practical potential.

Chapter 2 - Literature Review

Coffee is the most traded commodity in international markets and one of the world's most widely consumed beverages, making caffeine the most popular legal drug globally (Weinberg and Bealer 2001; Courtwright 2001). A legendary of story about coffee discovery is mentioned by Ukers (1935) and Wellman (1961). According to these authors, the origin of coffee is Ethiopia. A goat herder whose name was Kaldi first discovered coffee berries. Kaldi realized that when his goats ate the berries, their energy level increased and they could not sleep at night. Kaldi reported his findings to the monastery's abbot, and a monk tested Kaldi's story by making a drink using the coffee berries, which produced the same effect. Other monks began consuming this berry drink to increase their energy, and the consumption of coffee began to spread from Ethiopia to the Arabian Peninsula in the late 1400s. By the 16th century, coffee was being cultivated in Yemen, Persia, Syria, and Turkey. Pilgrims to the Muslim city of Mecca experienced coffee, or the so-called "wine of Araby," and popularized its use as an energy booster around the world (Wellman 1961).

The consumption of coffee did not expand smoothly. According to Ukers (1935), when European travelers to the Near East brought the "dark black beverage" to Europe in the 17th century, it was referred to as the "bitter beverage of Satan." However, when Pope Clement VIII tasted the drink and found it satisfying, the controversy appeared to subside with his "blessing its use in good Christian homes." At the same time, it became common to serve coffee in cafes and in public in England, France, the Netherlands, and Germany. The drink was recognized as an elixir for people encouraging "intelligent conversations." It was known as the "penny university" in England since the price of coffee was one penny in coffee houses and its consumption seemed to encourage conversations. Throughout Europe, coffee replaced beer and wine as a common breakfast drink (Ukers 1935). Coffee became the beverage of choice globally over time (Mussatto et al. 2011; Obruca et al. 2015), valued for the alertness and energy it provides compared lameness of tea and the intoxicating effects of alcohol.

As demand for coffee increased, organized coffee cultivation began to emerge. By the 17th century, the Dutch had successfully cultivated it in Batavia, a city on the island of Java in Indonesia (Hall and van de Koppel 1946; Cramer 1957). The Dutch expanded their production to other Indonesian islands, including Sumatra, an island west of Java, and Sulawesi, an island east of Borneo and formerly called Celebes. These islands, thus, became the first major traders in coffee.

Coffee spread to the Americas in 1723 when Decalieux, a French naval officer, sailed to Martinique with a seedling from the coffee plant. The mayor of Amsterdam at the time offered the coffee seedling to Louis XIV, and it was planted in the French Royal Botanical Garden (Dufrenoy and Dufrenoy 1950; Clarence-Smith & Topik 2003). The single seedling spread across the Caribbean and South and Central America. Spread of coffee has been expanded and cultivated wherever the climate and the topography allowed its production by building coffee plantations. The flexibility and attractive nature of coffee has contributed significantly to its position as the most traded agricultural commodity and a globally consumed beverage (Weinberg and Bealer 2001; Courtwright 2001).

2.1 Major Coffee Species

Since coffee was discovered approximately 600 years ago, humans have become deeply involved with its cultivation (Wellman 1961; Chevalier 1929). Coffee beans belong to the *Rubiaceae* family, which comprises over a hundred coffee species of the genus *Coffea*. The two species dominating global trade are *Coffea arabica* and *Coffea canephora* or *Coffea robusta*. *C. arabica* accounts for about 75% of global coffee output, while *C. canephora* or *C. robusta* accounts for the remaining 25% (Belitz et al. 2009; Etienne 2005).

Although Arabica is native to Ethiopia and is considered the original coffee, its name reflects an error made by botanist Carolus Linnaeus. Linnaeus incorrectly believed that Arabica originated on the Arabian Peninsula (Coffee and Cocoa International 2019). However, Arabica has been proven to be an amphidiploid formed by hybridization between *C. eugeniodes* and *C. canephora*, or eukaryotes related to these diploid species (Lashermes et al. 1999). In other words, Arabica is a hybrid formed from Robusta and another species. While Robusta coffee plants and all other wild coffee species have 22 chromosomes, Arabica has 44 because of its hybrid characteristics. For that reason, it is impossible to cross Arabica with other coffee species to produce a hybrid (Illy 2002).

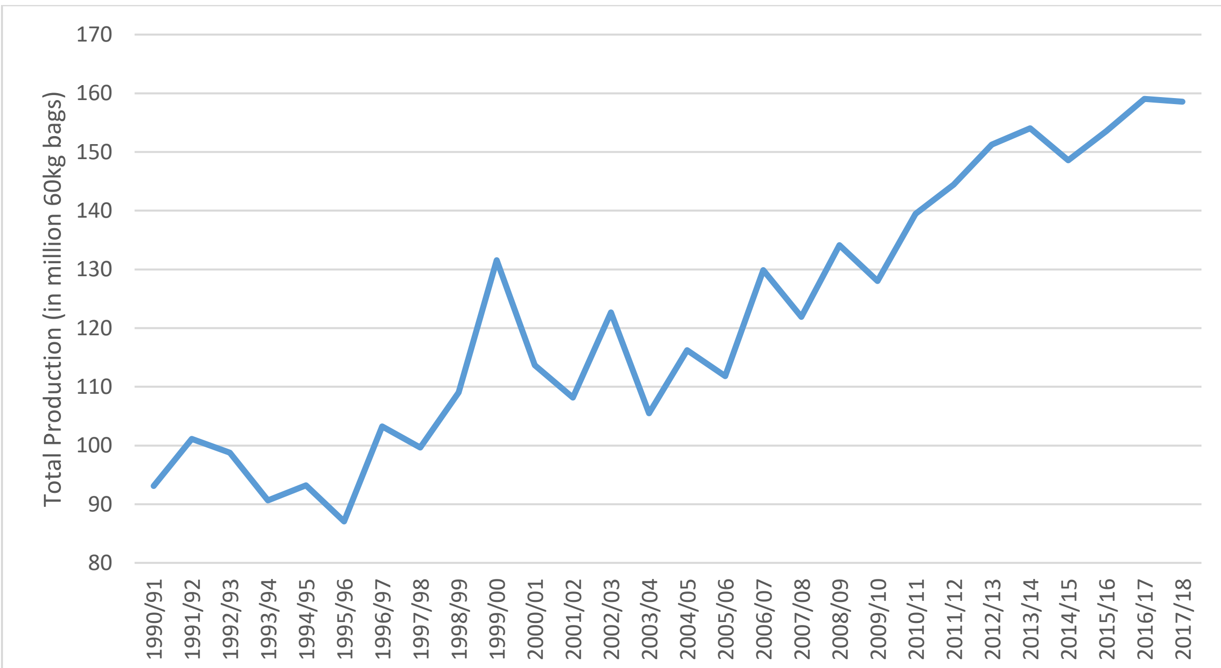
Robusta has a bitterer taste than Arabica because of its higher caffeine content; in fact, Robusta contains approximately double the caffeine content of Arabica, or 2.7% compared to 1.5% (Coffee and Cocoa International 2019; Illy 2002). Arabica also has a smoother taste than Robusta because it contains double the concentration of sugar as Robusta and about 60% more lipids. As a result, the taste of Arabica is generally preferred over Robusta.

Both Arabica and Robusta are cultivated in countries lying between the Tropic of Cancer and Tropic of Capricorn where there are few seasonal changes (Bliss 2017). However, the agronomic requirements of Arabica and Robusta are different. For example, while Arabica grows upwards of altitude 550-1,000 meters with temperature of 16-24°C and 1,000-2,000 meters above sea level in the area near to the equator, Robusta grows around 900 meters above sea level with relatively warmer temperature than Arabica. Arabica also has relatively lower yields compared to Robusta. (Bliss 2017).

2.2 Global Coffee Market

The International Coffee Organization (ICO) lists approximately 56 countries as coffee-exporting. The total global production for these countries has been continuously increasing, from about 93.1 million 60 kg bags produced in 1990/91 to nearly 160 million 60 kg bags produced in 2017/18. Average annual growth rate of production exceeds 2.1% (Figure 2.1). In 2017/18, ten major coffee-producing countries accounted for a total of 88.7% of the global production of coffee, while the top four countries accounted for about 75%.

Figure 2.1: Global Coffee Production 1990/91-2017/18 Production Year (All Exporting Countries)

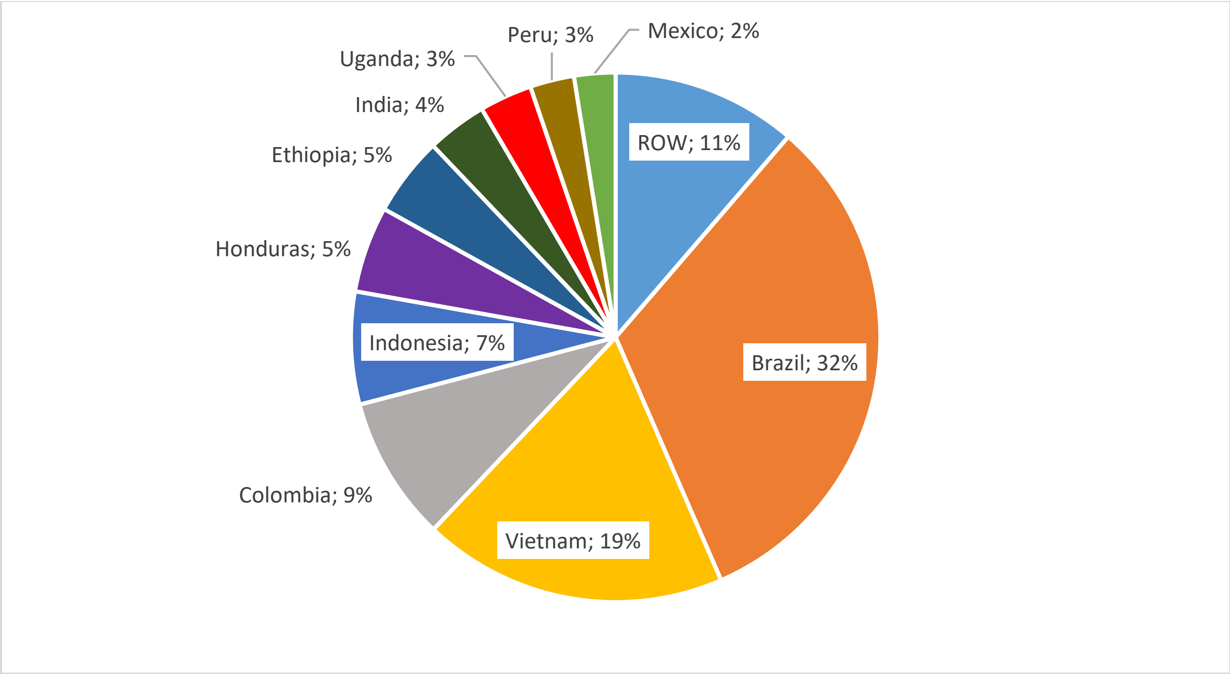


Source: ICO 2019 (http://www.ico.org/new_historical.asp?section=Statistics)

Coffee production by different countries has changed over time. For example, Figure 2.2 shows that the ten major producing countries together accounted for approximately 89% in 2017/18. Brazil, as the top producer in the world, accounted for about 32% of global production. Brazil was followed by Vietnam, accounting for 19%, and Colombia, accounting for 9%. Uganda's share of the global coffee output in 2017/18 was about 3%. In 1990/91, Brazil was still the top global producer, but Vietnam's share was only 1% while Colombia's was 15% (Figure 2.3). Uganda's share was 2% as one of the ten major producing countries in 1990/91.

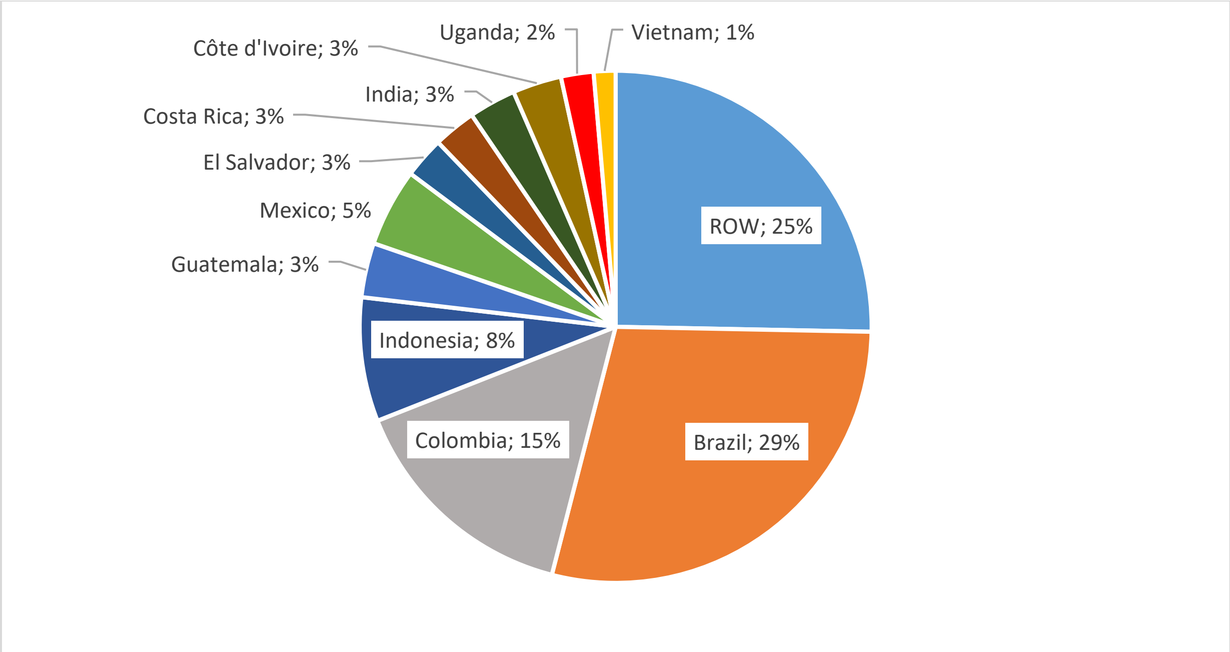
The rise of Vietnam over the years as a major coffee producing and exporting country is considered a major success story and provides an opportunity for imitation. The Vietnamese government's systematic and consistent investment in the industry is credited as the primary source of the country's transformation of its coffee industry. Although the French introduced coffee to Vietnam in 1857 using the agricultural estate production system, many plantations were destroyed during the Vietnam War, and production subsequently decreased. Since 2010, the Vietnamese government has been implementing its New Vision for Agriculture, the purpose of which is to advance sustainable, large-scale production in all agricultural sectors, including coffee production. The New Vision aimed to increase Vietnamese coffee competitiveness by improving the crops' overall quality and productivity (Grow Asia Singapore 2016). The government's strategy involved the adoption of public-private partnerships across the coffee supply chain, with companies such as Nestle and Syngenta supplying seeds and crop protection while Yara, the world's largest fertilizer company, provided fertilizer. The government also partnered with Syngenta and Nestle to provide training for farmers and extension agents to train additional farmers. On the marketing side, the strategy focused on branding and on sustainability efforts to extract higher price premiums.

Figure 2.2: Distribution of the Top 10 Coffee-Producing Countries and the Rest of the World (ROW) in the 2017/18 Production Year



Source: ICO 2019 (http://www.ico.org/new_historical.asp?section=Statistics)

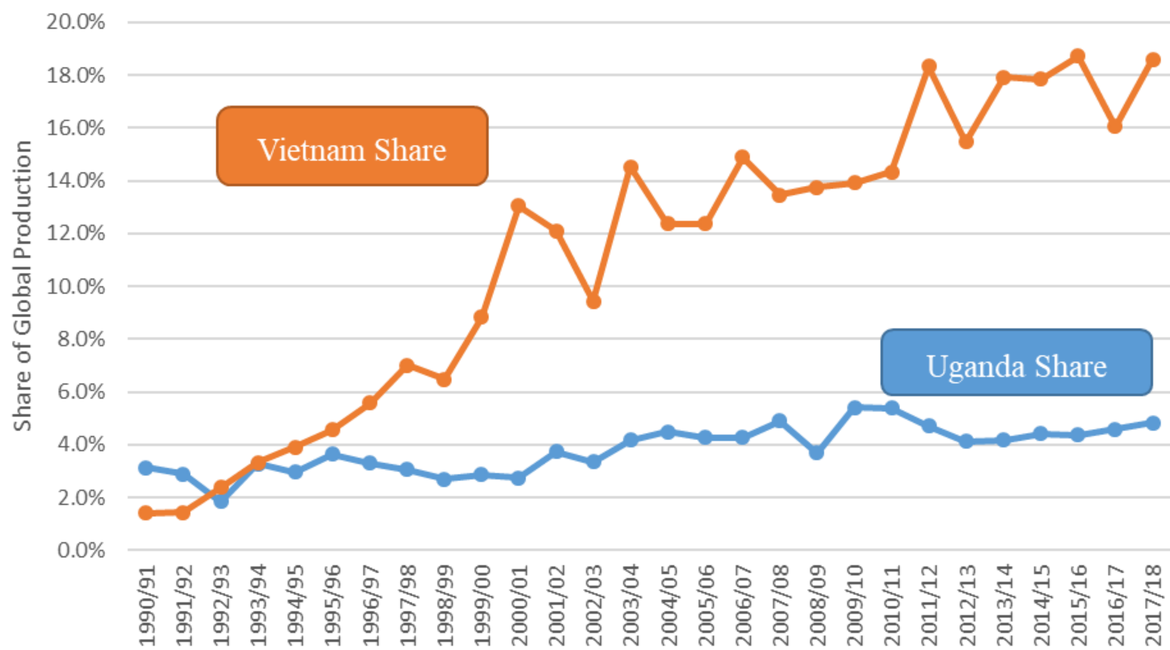
Figure 2.3: Distribution of the Top 10 Coffee-Producing Countries and the Rest of the World (ROW) in the 1990/91 Production Year



Source: ICO 2019 (http://www.ico.org/new_historical.asp?section=Statistics)

The policy initiatives undertaken by the Vietnamese government contributed to the average crop yield increasing by 12% from 2011 to 2015 and by 17% between 2015 and 2016. Producer profitability also increased by 14% from 2011 to 2015. During the same time period, the Vietnamese coffee industry reduced its carbon emissions by 55% by optimizing chemical fertilizer use and reducing its water footprint by 66%. The industry also reduced its use of fertilizer by 18% to 23% depending on location. These harmonized efforts by the coffee supply chain, supported by a deliberate and consistent approach, may explain the rapid rise of Vietnam's position in the global coffee market.

Figure 2.4: Vietnam's and Uganda's Shares of Global Production (1990/91-2017/18)



Source: ICO 2019 (http://www.ico.org/new_historical.asp?section=Statistics)

The performance of Vietnam's coffee production is contrasted with Uganda's in Figure 2.4. This figure highlights the potential benefits of structured policies to enhance industry performance. At the beginning of the period under consideration, Vietnam's share of global production was about half of Uganda's. However, since the 1992/93 production year, Vietnam has made great progress, while Uganda's production has been relatively stagnant. The average growth rate in Vietnam's share of global production was about 8.3% per annum compared to Uganda's of 2.4% during this period. For Uganda, the supply of seedlings to farmers under the National Coffee Policy could help increase production. However, Vietnam's success story tells us that aggressive and multiple initiatives are necessary. This exploration of value addition's potential in enhancing producer profitability could lead to additional policy initiatives that promote Uganda's success on the global coffee market.

2.3 Coffee Production in Uganda

Coffee has played an important in the Ugandan economy for the past several decades, although coffee has been grown in Uganda even longer. Rosner (2014) quoted Aaron Davis's study showing that wild varieties of coffee have long been produced in Uganda, with some more than 100 years ago, noting that "some taste awful, but all of it produces a recognizable coffee-like aroma if you roast the bean" (p. 73). Uganda's wealth in the colonial period was concentrated among its southern peoples through the production of cotton and coffee as the country's primary cash agricultural commodities. Twaddle (1973) reported that through collaboration with southern chieftains, cotton and coffee became the first cash crops introduced in Uganda, enabling colonial leaders to cover basic costs through exports and focus on political stability. Because of the role of coffee in colonial Ugandan economy, coffee diseases and pests were also studied in the early 1900s (Small 1921; Anon 1913).

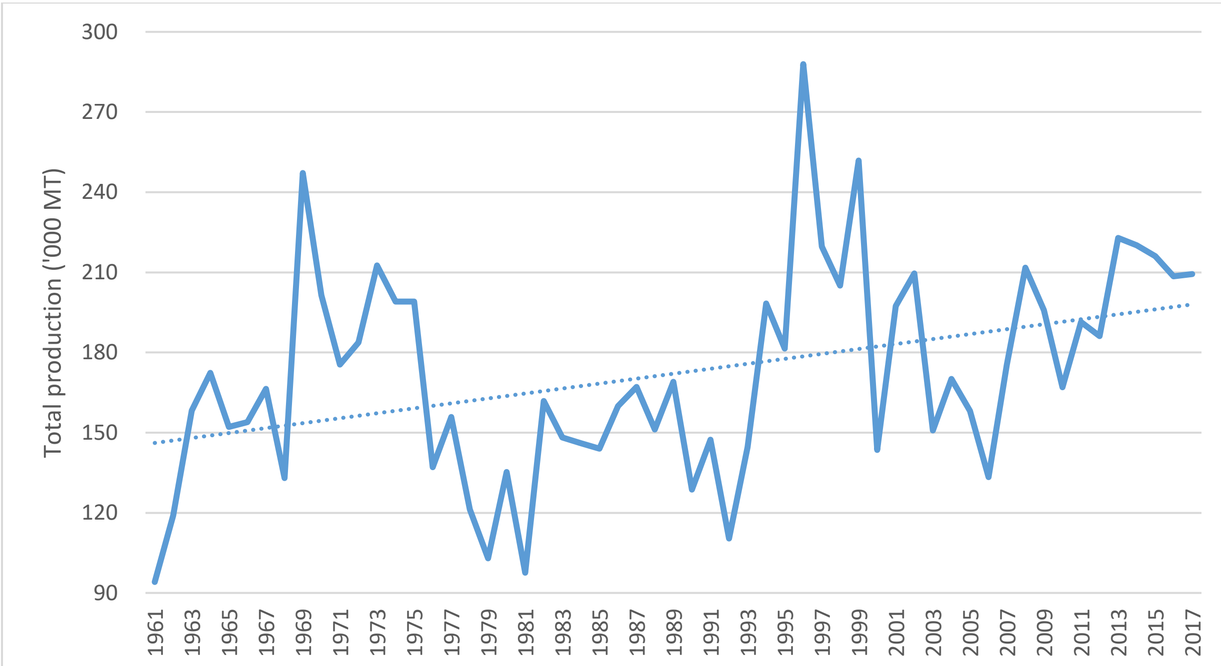
There are four regions (Central, Western, Northern and Eastern) and 134 districts in Uganda. Figure 2.5 shows that coffee is grown in all four regions and almost all districts, with the exception of a few districts in the Northern and Eastern regions. Arabica is grown in three districts in the Western Region (Bundibugyp, Ntoroko, and Ksoro), two districts in the Northern Regions (Zombo and Nebbi), and eight districts in the Eastern Region (Bukumbuli, Kween, Bukwa, Kapcharwa, Sironko, Manafuwa, Bududa, and Mbale). On the other hand, Robusta is grown in all districts where coffee is grown, except for the Arabica-only districts. The topography of Arabica-only districts hinders the effective production of Robusta. Districts where only Arabica is grown are limited to a few locations in the Eastern, Western, and Northern areas. In a select few districts, mainly in the West Southern Regions, both species are produced, though the average coffee farm size is relatively small.

Figure 2.5: Coffee-Growing Districts in Uganda by Variety

Source: UCDA 2017

Figure 2.6 shows the trend in coffee production in Uganda from 1961 through 2017. The figure demonstrates that production has been very variable over the years, reaching its peak more than two decades ago in 1996, when total production was 288,000 MT. The figure also shows that there have been 30 annual declines and 27 annual increases in coffee production since 1961, but the general trend is upward, albeit very slow growth rate of about 0.6% per annum.

Figure 2.6: Coffee Production in Uganda (1961-2017)



Source: United Nations 2017(http://www.fao.org/faostat/en/#data/QC)

Coffee prices are determined by its organoleptic properties, chemical composition, and bean morphology as a result of its supply and demand characteristics. As a result, Arabica commands a higher price in the market (Soares, Alves, and Oliveira 2014). Additionally, Ugandan coffee prices are determined by variety and grade in the domestic market. Grade is measured by quality and size of coffee beans. There exist 10 grades for Robusta and 33 grades for Arabica. The Robusta grades are mostly determined by size of bean, while the Arabica grades reflect place of origin (e.g., Sipi Falls, Mount Elgon, White Nile, etc.). According to the Uganda Coffee Development Authority (UCDA), in 2016/2017, the coffee with the highest quality Robusta grade was the Organic Robusta, with an average price of $2.23 per kg (UCDA 2017). The ungraded (or other) Robusta grade, which was the lowest grade and price available, was priced at $1.30 per kg (UCDA 2017). Sipi Falls was the highest priced grade of Arabica at $3.96 per kg, while ungraded (other) Arabica grade had the lowest price at $1.36 per kg.

2.4 Overview of Coffee Development Policy in Uganda

Prior to national agricultural sector reforms, the government was the only buyer of coffee and coffee prices were controlled (Ahmed 2019). The Coffee Board managed all aspects of coffee, including exports operating under the Coffee Act. After market liberalization in the early 1990s, coffee trade and price were deregulated (Hill 2010) and private coffee traders started emerging. The government's role was thereafter limited to quality assurance (Uganda Gazette 1994).

According to Baffes (2006), Uganda has several key statutory body institutions such as the Uganda Coffee Development Authority (UCDA), the Coffee Research Institute (CORI), the Uganda Coffee Trade Federation (UCTF), and the National Agricultural Advisory Services (NAADS). The UCDA acts as a coffee marketing board, while CORI and NAADS concentrate on research and extension services. The UCDA was established to oversee the coffee industry, product promotion, value addition, and quality improvement in Uganda.

The Uganda Coffee Development Authority (UCDA) was established in 1991 upon market liberalization, and it was charged with helping coffee farmers improve production, quality, and marketing by providing them with extension, research, and export market information. The UCDA also allowed regional governments to use traders' registration fees to support coffee farmers in their regions (Ahmed 2019). Because of the commitment to free trade policy in Uganda, there are no taxes on coffee producers or sellers. However, there does exist a 1% levy on export revenue for exporters, which finances the UCDA (Ahmed 2019). The UCDA has provided support to 1.7 million coffee-producing households, and the organization aims to facilitate the replanting of coffee trees, increase yields from aging coffee trees, and expand coffee-growing lands. The UCDA also provides programs supporting value-added activities such as certification programs, traceability in the coffee supply chain, developing processing standards, roasting for domestic consumption, and promoting on-farm and processing technology.

Previously, the Coffee Act of 1962 authorized the Coffee Marketing Board (CMB) to maintain a monopolistic power on over 85% of sun-dried Robusta coffee sales. For this reason, private exporters and cooperatives focused on wet-dried Robusta and wet-dried Arabica beans. The CMB strengthened its power as an organization through processing, quality control, and marketing activities. After farmers or cooperatives hulled the coffee, all coffee beans were sold to the CMB. For this reason, the CMB contributed around 50% of the government's revenue through coffee exportation. Because of its monopolistic control authorized by the government, the CMB was able to delay payment to farmers for coffee. Furthermore, producer price was extremely low, and farmers were unable to expand their businesses through financing due to the high risk of inflation and financial losses. This state-controlled system was abolished in 1989 after the International Coffee Agreement increased producer prices and diminished the power of the CMB monopoly. As aforementioned, the UCDA was later established in 1991 by the government as a marketing and promotion board. Since the liberalization of the coffee market, the private sector of coffee production and processing has dramatically increased, with numerous private companies, cooperatives, and other joint ventures investing in the coffee sector and supply chain (Collinson et al. 2005).

The recent Coffee Roadmap designed by the UCDA supports value addition by branding Uganda coffee and supporting local coffee business, supporting producer groups and joint ventures, and improving access to quality agricultural inputs (Collinson et al. 2005). Moreover, the UCDA holds workshops to help farmers increase production, improve product quality, and organize farmers' groups and field school sessions. The UCDA also works to train processors and buyers on processing standards, as well as demonstrate technology sites to be established (Office of the Auditor General of Uganda 2016). In terms of value addition, the Coffee Roadmap facilitates Uganda coffee branding to drive demand and improve product value. The Coffee Roadmap also recommends coffee farms participate in post-harvest value addition and investment in instant coffee plants. To increase production, the Coffee Roadmap reinforces farmers' associations and producer cooperatives, providing favorable investment circumstances in the coffee sector. The roadmap further supports joint ventures between investors and middle-class owners of underutilized or undeveloped land. Finally, the Coffee Roadmap seeks to improve the quality of production inputs such as fertilizer and pesticides while also increasing the quality of seedlings and improving access to credit for smallholders.

The UCDA Coffee Roadmap supports numerous policies, including the Agriculture Sector Development Strategy and Investment Plan (DSIP), the draft National Coffee Strategy, the Uganda National Coffee Regulations Statute 1994, and other efforts to support coffee value chains and increase Ugandan farmers' opportunities and benefits (Kilimo Trust 2012). These various organizations and institutions work to structure the coffee value chain, promote high quality products, develop storage systems, fight the coffee wilt disease, and increase market access by producer enterprises (Kilimo Trust 2012).

There are several policies supporting the Uganda coffee sector, including the National Planning Authority's National Development Plan 2 of 2015/16-2019/20; the Ministry of Agriculture, Animal Industry, and Fisheries' Agriculture Sector Strategic Plan (ASSP) of 2015/16-2019/20; and the Uganda Coffee Development Authority's Coffee Roadmap, National Coffee

Policy 2013, and National Coffee Strategy 2015/16-2019/20. According to the National Development Plan 2 of 2015/16-2019/20 developed by the National Planning Authority, coffee is one of 12 major crops in Uganda, and the government of Uganda plans to invest in coffee to strengthen the value-chain. To meet this objective, the government of Uganda will implement an extension system, improve research related to agricultural products, facilitate the adoption of technology in farming households, promote the effective use of inputs, advocate for sustainable land use and soil management, support female farmers, and improve agriculture-related institutions. The Agriculture Sector Strategic Plan (ASSP) of 2015/16-2019/20 includes strategies to improve the coffee sector, such as adopting proper agronomic practices and input uses at the farm level, expanding coffee land, providing extensions for coffee and developing business initiatives, and supporting producers' groups.

2.5 Value Addition Opportunities for Coffee Farmers

According to Amanor-Boadu (2003), value addition can be both a metric and a concept. As a metric, it is the difference in value accruing from the transformation of particular inputs into outputs. As concept, value addition describes all activities undertaken at a node in the supply chain which have previously been undertaken a different node. Thus, the processing of grain into flour at the farm level is value addition because the grain farmer can extract the value of the flour in addition to the value of the grain when the flour is sold. Amanor-Boadu argued that the size of the reward is proportional to the size of the reward experienced by the customers. This reward may be monetary or non-monetary. In terms of monetary rewards, the agent undertaking the value addition may extract a higher price premium when the product sold. The non-monetary rewards of value addition include loyalty, higher volumes of purchases, and product mandates for supplying particular markets.

Amanor-Boadu (2003) presented a six-dimension framework to demonstrate value-added activities to produce the value-added opportunity slate. The six dimensions are time, location, product or service, process or method, information, and incentive. Each of these dimensions engenders an operational opportunity depending on whether value addition is being perceived through the innovation or the coordination lens.

Figure 2.7: Value-Added Opportunity Slate Adapted from Amanor-Boadu (2003)

Dimension	Innovation	Coordination
Time	Speed	Just-in-Time Services
Location	Convenience	Efficiency and Co-Location
Product or Service	Form	Logistics and Delivery
Process or Method	Technology	Inter-Organizational Relationships
Information	Safety, Ethics	Information Systems
Incentive	Motivators	Transparency

Source: Amanor-Boadu 2003

The relative size of Ugandan coffee producers in comparison to their downstream counterparties means that the coordination perspective is not very applicable to value addition. Therefore, value addition is conceived of through the innovation lens. By eliminating wait costs or aggregation costs and transportation costs, farmers may provide products in a timely manner to increase their value to customers. As Figure 2.7 demonstrates, the most applicable value addition activity for coffee farmers in Uganda would be offering their customers different product forms though processing. They might also deliver products to a particular location specified by the buyer.

Figure 2.8 shows the three forms of coffee products that farmers may sell. The non-value-added form is fresh red cherries (left picture of figure). Fresh cherries are highly perishable because of their high moisture content. However, selling fresh cherries provides farmers the advantage of harvesting and delivering the product to a buyer as-is. The farmer may change the form of the product by drying the red cherries (middle picture). The drying process eliminates moisture from the product to increase its shelf life and decrease transportation cost. This process creates an additional cost for the farmer, which can be returned with interest in terms of increased product value. Finally, green coffee beans represent the farmer's third and highest value option for their buyers (right picture in figure). In this process, the farmer not only dries the fresh cherries but also removes the hull from the green bean. When farmers sell coffee beans in this final form, buyers can bag the green beans in their branded packaging for shipment to the final customer without accruing any additional processing costs.

Figure 2.8: Product Forms Sold by Coffee Farmers

Sources: UCDA 2019d

Undertaking value addition is not without risk. Apart from the costs generated by performing value addition activities that are not traditionally performed at one's level in the supply chain, there are risks associated with quality assurance and loss reduction. Without proper knowledge, skills, and equipment, drying red cherries could result in bacterial or other microbiological contaminations, which could reduce the value of the batch. Removing the coffee bean's hull may require investing in specialized equipment and skilled equipment operators. Additionally, such investments carry their own risks. For example, farmers may invest in equipment that does not have the requisite flexibility to address the specific and changing requirements of individual customers. When the cost of value addition exceeds the value added to the product, producing the product becomes unsustainable.

More than 60% of a coffee bean's overall quality is determined by post-harvest processes such as drying and hulling (Hameed et al. 2018). For this reason, characteristics such as the taste and aroma of coffee are sensitive to the drying method and the drying environment. The natural-dry method, which is common in Uganda, enables farmers to produce majority of the total export value of Robusta and more than half of Arabica coffee. Natural drying involves drying coffee beans under the sun before removing outer layers manually (Hameed et al. 2018). The moisture content of the cherry beans should be between 10-12% to avoid fermentation, which degrades the value of the coffee. Accordingly, post-harvest drying is important to maintain the quality of the coffee. However, because the natural drying method utilizes beds on the bare earth, tapes, and other surfaces, coffee beans are vulnerable to dust, contamination by microbes, unexpected rain showers, and high temperatures (greater than 28ºC), all which decrease the quality of the coffee (Hameed et al. 2018). Additionally, coffee drying farmers in Uganda do not invest significantly in drying facilities, meaning there is a higher risk of contamination by microbes or dust. If the coffee is dried after it has been contaminated and fermented by the microbes, the taste and aroma of the coffee suffers.

The wet-drying method is not the most common among Uganda farmers, majority of Robusta coffee production is processed using natural-drying method, 60% of Arabica production is processed using natural-drying method and the rest of it is processed using wet-drying method (UCDA 2017). There are three steps of wet-drying method: (1) removing pulp of coffee cherries by machine and putting in water to make the mucilage of the coffee bean easily removed by activity of microbe, (2) washing to remove mucilage, and (3) drying under the sun until the moisture contents of coffee bean becomes 12% (Hameed et al. 2018; eatcultrued.com 2017; UCDA 2019c). The semi-wet method skips the washing and removes mucilage using machine. Once drying under the sun is finished, coffee beans are still surrounded by a yellow layer, which is called parchment. The parchment is removed by exporters, becomes clean green coffee beans. Unlike the natural-drying method, the quality of beans treated using the wet-drying method depends greatly on the operation processes. The wet- or semi-wet method uses specific groups of microbes and bacteria for the fermentation, which plays a significant role in the taste of the coffee. Accordingly, the quality of the final products is highly dependent on the metabolic compounds (de Melo Pereira et al. 2014; de Melo Pereira et al. 2015).

In Uganda, using natural-drying method is more common for farmers than wet-drying method. One reason for this is that the majority of coffee farmers in Uganda are Robusta growers, and Robusta is typically treated with the natural-drying method. Furthermore, the quality of coffee made using the wet-drying method affects the final beverage quality, and exporters may be wary of the quality degradation that can occur during wet-dry processing. The more prevalent Arabica coffee product in Uganda, *Drugar*, is made of Arabica coffee processed with the natural-drying (sun-dry) method, accounting for around 60% of Arabica production in Uganda (UCDA 2017).

Using the context of this information regarding coffee production in Uganda, this study identifies the characteristics of Ugandan coffee farmers who are engaged in value addition, as well as the type of value addition these farmers engage in. The study assesses whether the identified characteristics differ between farmers engaging in or not engaging in value addition. The performance of farmers providing value-added services is compared to the performance of farmers who do not provide value-added services, and the factors influencing these differences, if any, are explored.

Chapter 3 - Study Area, Data and Methods

Chapter 3 provides a description of the study area, and the data and the conceptual models used to achieve the study's objectives. Along with the study area and data, the operational environment and decision framework of Ugandan farmers are also explored to facilitate a better understanding of the challenges these factors represent to the analyses. Finally, the conceptual models are defined encompass descriptions of the statistical and econometric models used for the empirical segments of the research.

3.1 Study Area

Uganda is a landlocked country in East Africa. It shares borders with five countries: Kenya, the Democratic Republic of the Congo, South Sudan, Tanzania, and Rwanda (Figure 3.1). The southern border of Uganda is encompassed by a substantial portion of Lake Victoria, which it shares with Kenya and Tanzania. The total land area of Uganda, including its lakes, is approximately 241,038 km^2. Uganda lies within the Nile Basin and experiences varied but generally tropical climate with two rainy seasons per year. As in most countries, changes in technology, population pressures, and government interventions have been affecting Uganda's available arable land. The percentage of Uganda's land that is available and arable increased from about 18.9% of total land area to approximately 34.4% between 1967 and 2016. This increase is primarily the result of reduction of Uganda's forests (Central Intelligence Agency 2019).

The official population of Uganda in 2018 was around 41 million. Uganda has one of the youngest population in Africa, as individuals under 25 years old account for almost 70% of the total population and individuals between 25 years and 54 years old make up about 26.5% of the population. The life expectancy at birth in Uganda, which is estimated at 56 years, is the 217th highest in the world, ahead of only six other countries (Mozambique, the Central African Republic, Somalia, Lesotho, Zambia, and Afghanistan). Its population growth rate is relatively high at about 3.2% per year, ranking sixth in the world behind Syria, Angola, Malawi, Burundi, and Chad. Uganda's population density is relatively higher than that of its neighbors, with the majority of the population living in the southcentral parts of the country. The highest population concentrations occur around Uganda's two major lakes: Lake Victoria and Lake Albert. Uganda's northeast regions are the least populated. Additionally, urbanization rate in Uganda is very high, estimated at about 5.7% based on 2015-2020 data, even though its urban population comprises only a quarter of the nation's total population (Central Intelligence Agency 2019).

Figure 3.1: Uganda Political Map and Neighboring Countries

Source: Google World Map: Uganda. (https://www.pinterest.com/pin/773493304728096661/?nic=1a).

Based on the 2017 estimate of Uganda's GDP at $89.2 billion (on the purchasing power parity basis), the per capita income in Uganda is approximately $2,400, the 200th highest per capita income in the world. The government accounts for only 8% of Uganda's GDP, while household consumption accounts for almost three-quarters. For the purpose of comparison, the United States government accounts for 17.3% of the nation's GDP, whereas household consumption accounts for 68.4% (Central Intelligence Agency 2019). Furthermore, exports made up only 18.8% of Uganda's GDP, while investment in fixed capital accounted for about 24%. If these investments are going into infrastructure and other economic growth enabling assets, then the economy should respond accordingly to them soon, facilitating expansion in government revenue, reduction in the country's fiscal constraints, and a potential increase in the Ugandan government's share of the GDP.

Agriculture represents Uganda's largest economic sector, accounting for 71% of the country's employment and 28.2% of the GDP in 2017 (Central Intelligence Agency 2019). Its major agricultural products can be categorized as cash crops, food crops, and livestock. Cash crops include coffee, tea, cotton, tobacco, and horticultural crops such as fruits, vegetables, and flowers. Coffee is the leading cash crop as a major foreign earner. Finally, the major livestock produced in the country are beef cattle, dairy cattle, small ruminants, and poultry. Because of its large water resources, Uganda's fisheries industry is included in its agricultural sector.

The majority of agricultural producers in Uganda are smallholders, averaging less than 2 ha, with more than four million agricultural households. The Food and Agriculture Organization (FAO) (2013) reports that smaller farms with less than 1 ha of land account for nearly 90% of all farm holdings. Coffee is the leading export commodity, accounting for 16% of total exports, ahead of gold at 10%. The Uganda Coffee Development Authority (UCDA) reports that about 1.7 million households grow coffee, with an average coffee farm size of 0.18 ha (UCDA 2019b). Because of its important economic position in the Ugandan economy, coffee was regulated under a state-controlled system until 1989. Since that time, the UCDA has been established as the government agency responsible for the industry's development in terms of research, production, processing, and trade. The UCDA is responsible for providing planting material to farmers, and training to farmers and others in the coffee chain, conducting market research and disseminating such information to industry stakeholders. The UCDA is also responsible for facilitating and enforcing quality improvements in the industry. In recent years, there have been attempts to promote domestic coffee consumption in the hopes of reducing the Ugandan coffee industry's over-dependence on exports.

In a recent report, the World Bank argued that "with agriculture employing 70% of Ugandans, there is a need to close [the] potential performance divide through commercialization, value-addition and trade" (World Bank 2018). Arguing that value addition can increase farmer incomes and contribute to poverty reduction, this study seeks to explore the extent to which value addition can increase coffee farmers' realized prices and determine the factors that motivate on-farm value addition.

3.2 Data

To explore the extent of on-farm coffee value addition in Uganda, this study used data from the 2013/14 Uganda National Panel Survey (UNPS). These data were collected as part of the World Bank Living Standard Measurement Study-Integrated Survey on Agriculture (LSMS-ISA) project in cooperation with the Uganda Bureau of Statistics. The UNPS uses a questionnaire to collect information regarding households, women, agriculture, and communities at the household level, and at the plot level for agricultural production. The 2013/14 survey collected data from over 3,300 households. Data were collected across two visits aligned with the cropping seasons in Uganda. The first visit occurred in the second cropping season of 2013 (July through December), and the second visit occurred during the first cropping season of 2014 (January through June).

The UNPS is large and covers topics beyond the scope of this research. The survey is organized into four major sections: Household, Agriculture, Women, and Community. This study used variables from the first two sections (Household and Agriculture). Within those sections, the study drew only on the relevant data. For example, farmer demographic data were drawn from the Household section, while farm characteristics data were drawn from the Agriculture section.

The dataset described three types of coffee products: fresh/raw cherries harvested in pots or shells, dry cherries in pods or shells, and dry grain without pods. The study classified on-farm drying and shelling of fresh cherries as value addition. As a result, there were two levels of value addition identified in the dataset: (1) fresh cherries processed into dried beans in pods, and (2) dried beans in pods that were shelled and processed into green beans without shells or pods. Additionally, despite the larger sample of 3,300 respondents, this dataset comprised only 489 coffee growers, and the analyses were therefore limited.

Using secondary data presents some significant limitations. Because the survey and questionnaire were designed for specific purposes that differ from the questions posed for this research, there may be differences between the interpretation of certain variables and the original definition intended by the survey designers. Being aware of this risk, the study has taken care to explain as clearly as possible where differences in meaning may exist, having carefully explored the data dictionary underscoring the 2013/14 UNPS dataset.

3.3 Method

3.3.1 Theoretical Framework

While global coffee production has been increasing at about 1.6% per annum from 1961 through to 2018, the average growth rate in Africa over the same period is -0.1% per annum. Thus, Africa's share of global coffee production has declined from peak of about 34% in 1970 to about 11% in the late 2000s. However, due to higher demands from the Asian market, coffee exports from Africa to Asia has tripled over the last 20 years. Uganda is the second largest exporting country in Africa, after Ethiopia (ICO 2019).

Arabica coffee accounts for 25% of Ugandan coffee production and Robusta coffee accounts for the remaining 75% (UCDA 2017). Arabica coffee is produced in regions over 1,400 meters above sea level, while Robusta grows in areas between 900-1,400 meters above sea level. Ugandan coffee beans in general are of high quality due to the high altitude, soil conditions, and natural environment in which they are produced. Robusta coffee beans processed using the wet-drying method tend to be of high quality with a deep flavor (ICO 2019). Robusta coffee is produced in central Uganda near the Lake Victoria. Other regions include Busoga in Eastern Uganda for Arabica beans and Arua in Northwestern Uganda for both types of beans (ICO 2019). Some Robusta coffee beans in Uganda are produced in the nation's high-altitude regions in the Western area that borders the Democratic Republic of the Congo. These coffee beans are valued as some of the best quality Robusta coffee beans. Arabica beans are mainly produced in mountainous regions such as Mt. Elgon, Rwenzori, and the West Nile.

Uganda's Central Region is the location of 37% of the nation's coffee trees in production, making it the highest producing region. The Eastern and Western Regions account for 23% and 22% of the nation's coffee trees in production, while the North Eastern and South Eastern Regions account for 7% and 10% (Table 3.1). Central Uganda has the highest number of coffee producers at 611,000. Overall, it is estimated that 1.7 million farm households in Uganda produce coffee as a major or significant crop. The number of coffee trees owned per household is estimated at 231 trees in the Western Region, 222 in the Northern Region, 180 in the Central Region, 151 in the Eastern Region, and 114 in the South Western Region (UCDA 2008).

Table 3.1: Area Planted Compared to Coffee Trees and Farm Households by Region

Region	Area ('000 Ha)	Number of trees (million trees)	Trees in production (million trees)	Farm household ('000)	Average Number of Trees in Production per Household
Central	136	151	109	611	180
Eastern	77	86	73	486	151
Northern	19	27	20	92	222
Western	79	94	61	265	231
South-West	40	49	29	258	114
National	353	408	294	1,713	172

Source: UCDA 2008; ICO 2019

Agriculture in Uganda is a multi-cropping system. Coffee and bananas are often intercropped because coffee cultivation benefits from using the shade from banana "tree" leaves. The coffee cultivation season in Uganda is between March-May and September-December. Coffee harvest season differs across the country due to the differences in weather, which influence the main and fly (or secondary) crops (Table 3.2). The main coffee harvest season of both Arabica and Robusta is November-January in the Eastern Region, November-February in the Central Region, October-January in the West Nile area, and April-July in the Western Region some parts of the Central Region including Masaka (UCDA 2008; ICO 2019).

Table 3.2: Harvest Season by Region and Coffee Variety

<table>
<tr><th></th><th>Oct</th><th>Nov</th><th>Dec</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th></tr>
<tr><td>Central Region</td><td></td><td colspan="4">Main crop (Robusta)</td><td></td><td></td><td colspan="4">Fly crop (Robusta)</td><td></td></tr>
<tr><td>Eastern Region</td><td></td><td colspan="3">Main crop (Robusta)</td><td></td><td></td><td></td><td colspan="4">Fly crop (Robusta)</td><td></td></tr>
<tr><td>Bugisu/Sebei (Eastern)</td><td></td><td colspan="3">Main crop (Arabica)</td><td></td><td></td><td></td><td colspan="3">Fly crop (Arabica)</td><td></td><td></td></tr>
<tr><td>West Nile Region</td><td colspan="4">Main crop (Arabica)</td><td></td><td></td><td colspan="3">Fly crop (Arabica)</td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Western Region</td><td colspan="4">Fly crop (Robusta)</td><td></td><td></td><td colspan="4">Main crop (Robusta)</td><td></td><td></td></tr>
<tr><td colspan="4">Fly crop (Arabica)</td><td></td><td></td><td colspan="3">Main crop (Arabica)</td><td></td><td></td><td></td></tr>
<tr><td>Masaka Region (Central)</td><td colspan="3">Fly crop (Robusta)</td><td></td><td></td><td></td><td></td><td colspan="3">Main crop (Robusta)</td><td></td><td></td></tr>
</table>

Source: UCDA 2008; ICO 2019

Coffee producers in Uganda in general have less than 0.4 hectare of farmland, and 40% of the producers' households are female-headed (ICO 2019). Coffee plantation farms also exist in the Mubende district in the Central Region and the Kabrole district in in the Western Regions. Coffee plantation lands occupy approximately 5% of total coffee farmlands (ICO 2019). The average yield depends on the coffee species. The average yield of traditional Robusta coffee beans on farms utilizing neither fertilizer nor pest and disease management practices is 573 kg per ha of green beans (Mugoya 2017). On farms that do use the recommended fertilizer and pest/disease management practices, the yield of Robusta coffee is 118% higher at 1,247 kg per ha of green coffee beans. The average yield on plantation farms overall is 2,667 kg per ha (Mugoya 2017), nearly twice what it is on traditional coffee farms. This shows how improvements in husbandry could enhance yield and productivity for coffee farmers in Uganda.

The UCDA budgets for coffee production are presented in Table 3.3. This helps give some idea about the potential opportunities for traditional (small) coffee farmers in Uganda. The budget is built on planting Robusta coffee at 1,100 trees/ha could produce 6,111 kg of dried cherries in the 5th year after planting. They also assume that the farmers are following the production guidelines suggested by the UCDA.

Assuming a farm gate price for dried coffee cherries of UGX 2,700, that will be equivalent to a total revenue of UGX 16.5 million/ha. The total cost to produce Robusta dried cherries was budgeted at UGX 6.5 million. Following the costs structure for the harvest and post-harvest, manure costs were UGX 300,000, pruning costs were UGX 86,800, erosion control costs were UGX 60,000, fertilizer costs were UGX 1.5 million, tools costs were UGX 100,000, pest and disease control costs were UGX 200,000, herbicide costs were UGX 150,000, bags costs were UGX 244,440, weeding costs were UGX 400,000, transportation costs were UGX 500,000, labor costs were UGX 2.2 million, drying costs were UGX 210,000, and tarpaulin expenditure for drying was UGX 360,000. Accordingly, total costs were UGX 6.5 million, and net income from producing Robusta coffee was UGX 10 million (UCDA 2019d). The cost per kg for drying and tarpaulins was UGX 93, or 5.7% of total costs.

On the other hand, Arabica parchment production was 2,500 kg per hectare in the 5th year of planting (UCDA 2019a). Parchment coffee has value-added production, is produced after wet-dry processing, and has a yellow layer covering the coffee beans. It is normally hulled when it reaches exporters, producing shelled green coffee beans (Mutua 2000). The farm gate price of Arabica parchment coffee beans was UGX 7,000. Drying costs were UGX 175,000, tarpaulins costs were UGX 360,000 and sales revenue was UGX 17.5 million. Accordingly, the net income was UGX 11.1 million (UCDA 2019a). The cost of drying and tarpaulins per kilogram for the Arabica parchment was UGX 214, or 4.8% of total costs, which was higher compared to the production of dried Robusta cherries.

Table 3.3: Net Income per Hectare in the Fifth Year of Planting

Activities	**Robusta (Dried Cherries)**		**Arabica (Parchment)**	
	UGX/ha	*UGX/kg*	*UGX/ha*	*UGX/kg*
Manure	300,000	49		
Pruning	86,800	14		
Erosion Control	60,000	10	60,000	24
Fertilizers	1,544,000	253	2,296,000	918
Labor Applying Fertilizers	100,000	16	50,000	20
Tools	100,000	16	100,000	40
Pest and Disease Control	200,000	33	200,000	80
Herbicides	150,000	25	150,000	60
Tarpaulins	360,000	59	360,000	144
Bags	244,440	40	100,000	40
Weeding	400,000	65	400,000	160
Labor for Harvesting	2,095,200	343	1,875,000	750
Drying	210,000	34	175,000	70
Transportation from Home to Market	500,000	82	500,000	200
5% contingency	100,000	16	100,000	40
Total Cost	6,450,440	1,055	6,366,000	2,546
Quantity Harvested in Fresh Cherries (kg)	14,211		12,500	
Quantity Harvested in Dried Cherries (kg)	6,111			
Quantity Harvested in Parchment (kg)			2,500	
Farm Gate Price		2,700		7,000
Income	16,499,700		17,500,000	
Net Income	10,049,260	1,645	11,134,000	4,454

Source: UCDA 2019a; UCDA 2019d; and Author's calculations

The difference in the net incomes of dried Robusta cherries and parchment Arabica coffee was about UGX 1.1 million in favor of Arabica, essentially a result of price. While Robusta yield was higher, it was not high enough to compensate for its price disadvantage. For example, average yield of Robusta fresh cherries was 14,211 kg per hectare, compared to 12,500 kg per hectare for Arabica fresh cherries. According to the UCDA (2019b), the yield of Robusta green beans was between 600 to 1,200 kg per hectare and the yield of Arabica green beans was between 500 to 1,600 kg per hectare. The foregoing is supported by the 2010 study conducted by the United States

Agency for International Development (USAID) using 2007/08 data from the Bank of Uganda and the UCDA. In that study, the estimated production cost was US$ 0.53/kg, including US$ 0.03/kg for drying costs, suggesting that drying costs account for about 5.6% of total production costs for Robusta coffee. The estimated gross margin based on the assumed price of US$ 1.31/kg was estimated at US$ 0.78/kg for Robusta and $1.05/kg for Arabica. The principal source of the difference seems to be the price paid for Robusta versus Arabica, despite other production costs for Arabica being higher.

Table 3.4: Cost, Farm Gate Price, and Gross Margin of Valued Added Coffee Producers

US$/kg	**Robusta Dried Cherries**	**Arabica Parchment**
Harvesting Cost	0.08	0.07
Drying Cost	0.03	0.03
Pulping and Fermentation Cost	-	0.12
Other Production Costs	0.40	0.68
Total Cost	0.53	0.89
Farm Gate Price	**1.31**	**1.94**
Gross Margin	**0.78**	**1.05**

Source: UCDA 2008; USAID 2010

Table 3.4 also shows that the processing of Arabica coffee follows a different path from Robusta. The highest-grade processed Arabica beans use the wet-drying process. However, there are only 22 wet stations across the country (UCDA 2019b), which may explain why only 3% of Arabica is processed in those wet stations and 97% of it is processed at farm using hand pulpers (U.S. Agency for International Development 2010). Additionally, since wet drying is an out-of-pocket expense for Arabic farmers, Arabica farmers may be unable to use these wet stations even if they were more readily available. Credit or subsidy supporting the use of these processing facilities might change that.

Value addition from fresh cherries to dried coffee beans occurs through moisture elimination and shell removal. The fresh cherries are made up of about 65% moisture, and the dried bean’s optimum moisture content is 12%. Farmers undertaking value addition must ensure this optimum moisture content to preserve bean quality. The final weight of dried coffee has been estimated as a proportion of fresh cherries at 19.4%, including 12% by weight of moisture for optimum quality. This implies that 100 g of fresh cherries contains 65 g of excess moisture and 15.6 g of pulp and shell. This information is based on a study by Ghosh and Venkatachalapathy (2014) on Indian coffee processing.

However, it seems the moisture content and other losses associated with the processing of coffee depend on where the processing occurs. For example, Gutierrez et al. (2013) showed that the conversion rates in Uganda are 0.31 (fresh to dry cherries), 0.54 (dry to shelled beans), and 0.17 (fresh to shelled beans). That is, 1 kg of fresh cherries will produce 0.31 kg of dried cherries and 0.17 kg of dried shelled beans. However, in other African countries, the conversion rates have been estimated at 0.37 kg (fresh to dry cherries), 0.50 kg (dry to shelled beans), and 0.18 kg (fresh to shelled beans) (Mutua 2000). Table 3.5 presents these conversion rates and estimates an average transformation rate, which the study later uses to calculate the benefits associated with value addition. Despite the geographies, the differences are not very wide, especially for fresh cherries to shelled beans.

Table 3.5: Fresh, Dried Cherries and Shelled Beans Conversion Rates for Coffee in Selected Countries

	Uganda	**African Countries**	**India**	**Average**
Fresh to Dry Cherries	0.31	0.37	0.42	0.36
Dry Cherries to Shelled Beans	0.54	0.50	0.51	0.51
Fresh Cherries to Shelled Beans	0.17	0.18	0.22	0.19

Source: Gutierrez et al. 2013; Mutua 2000; Ghosh and Venkatachalapathy 2014

Gutierrez et al. (2013) conducted research into Robusta coffee farm profitability in the Luwero and Bukomansimbi districts of Uganda using farm-level survey data from 48 households. They found that the most common forms of coffee for sale are, in order, dried cherries, shelled coffee beans, and fresh cherries, which account for 70%, 18%, and 12% of total production, respectively. Thus, Gutierrez et al. showed that producers generally undertake value addition, with more than 80% of the total production sold as value-added coffee. Additionally, Gutierrez et al. provided the conversion rate and farm gate price of value-added coffee. The conversion rates of processed coffee are 0.31 (fresh to dry cherries), 0.54 (dry to shelled beans), and 0.17 (fresh to shelled beans). The farm gate prices per kilogram of fresh cherries, dried cherries, and shelled beans are UGX 900, 2200, and 4500, respectively. Given the weight loss in processing, the study must consider whether the prices received for dried cherries and shelled beans compensate farmers adequately.

This question can be answered by examining the comparative prices of the weight equivalents of dried cherries and shelled beans as fresh cherries. If 1 kg of fresh cherries produces 0.31 kg of dried cherries, then 1 kg of dried cherries is produced from 3.23 kg of fresh cherries. Likewise, if 0.17 kg of shelled beans is produced from 1 kg of fresh cherries, then 1 kg of shelled beans is produced from 5.88 kg of fresh cherries. If the price of fresh cherries is UGX 900 per kg, then the respective prices for dried cherries and shelled beans must be no less than UGX 2,910 and UGX 5,290, respectively. However, the reported prices for dried cherries and shelled beans are UGX 2,200 and UGX 4,500. Why would farmers accept these prices, which are 24% and 15% lower, respectively, than should be expected? Could it be that farmers see this loss of price as the premium they pay to ensure they have quality products to sell, given that fresh cherries' quality deteriorates rapidly after harvesting due to high moisture content and susceptibility to microbial activity?

As aforementioned, coffee is grown in all four regions of Uganda: Central, Eastern, Western, and Northern. The Central Region grows the most coffee, accounting for 38% of total coffee trees (ICO 2019). Again, coffee is essentially an export crop. Uganda produces more Robusta than Arabica, the latter of which is produced in small areas on the Western and Eastern borders of the country. According to a coffee importer, Atlas Coffee Importer (2019), the representative Arabica coffee produced in the West Rewenzori mountains is *Drugar*, natural-dried Arabica. In the past, both *Drugar* and wet-dried Arabica did not receive high prices on the market due to their low quality. However, recently farmers in the Western Region whose land's soil, climate, and altitude are suitable for producing high-quality Arabica coffee have begun investing in the production of high-quality Arabica. This demonstrates that education regarding the value of assets farmers possess can introduce positive changes in their investment behavior. Indeed, the UCDA (2017) reported that wet-dried Arabica coffee produced in the Rwenzori mountain, branded after Mt. Rwenzori, is being sold at US$ 2.20/kg, 11% higher than the average price of Arabica coffee. On the other hand, *Drugar*, natural-dried Arabica is sold at US$ 2.30/kg, 16% higher than the average price of Arabica coffee and 26% higher than the average price of Robusta coffee.

Thus far, this study has shown that value addition may be important to coffee farmers' performance (Gonzalez 2007; Susila 2005; Wilson et al. 2013; Luna and Wilson 2015). Value addition requires monetary investment, and that investment must produce a return corresponding with the initial investment to make the value addition process worthwhile. Returns are often measured as the price premium over and above the commodity or base product to which no value has been added. This study conceives of this measurement through the following equation:

$$V = \sigma f(Q) \tag{3.1}$$

where V is the value-added product, Q is the raw or commodity product, and σ is the transformation factor in the value addition process. The f(Q) function suggests that the transformation process may change given the level of Q defined through a specific functional form, f. For Ugandan coffee farmers drying their red cherries, the transformation process involves investing labor and time in putting the red cherries out to dry in sunshine, gathering them at night, and protecting them from rain, predators, and pathogens. The cost of the transformation process, C_σ, may be expressed as follows:

$$\begin{aligned} C_\sigma &= \omega\sigma f(Q) = \omega V \\ \frac{\partial C_\sigma}{\partial Q} &= \omega\sigma f^{'}(Q) = \omega V^{'} \end{aligned} \tag{3.2}$$

where w is the unit cost of transforming Q to V using the transformation factor. The transformation cost must be regained through a higher premium on the price of the transformed product. Thus, if the commodity price of red cherries is p, then the price of the value-added beans, p_σ, may be defined as:

$$p_\sigma = p + \phi(C_\sigma) \tag{3.3}$$

where $\phi(C_\sigma)$ is the premium (greater than zero), defined as a function of the cost generated by the value addition process. If farmers' expectations about $\phi(C_\sigma)$ are below a certain threshold, then value addition will not occur because it becomes economically infeasible. It is only when $\phi(C_\sigma)$ exceeds this minimum threshold that farmers will choose to undertake value addition. The assumption, therefore, is that the only reason for farmers to undertake value addition is increase their net profit after spending the cost of value addition.

The exploration of the transformation occurring during value addition among coffee farmers in Uganda shows that the theoretical foundation for value addition may not hold true in this case, as the price received from adding value on a weight for transformed weight basis, p^w, may be lower to account for insurance premiums to preserve quality.

Fresh cherries have 349% more moisture than dried cherries, whereas shelled coffee beans have 36% less moisture lower weight as a result of the removed hulls. Therefore, 1 kg of shelled coffee beans may be produced from 4.5 kg of fresh cherries, and 1 kg of dried cherries may be produced from 2.3 kg of fresh cherries (Ghosh and Venkatachalapathy 2014). The effect on price of these transformation factors can be determined when the price of fresh cherries is used as the reference from which to establish the threshold below which value addition will not occur.

$$p_\sigma - p = \pi_\sigma > \phi(C_\sigma) \tag{3.4}$$

Therefore, value addition is a dichotomous decision variable:

$$V = \begin{cases} 1 \; if \; \pi_\sigma > T \\ 0 \; if \; \pi_\sigma \leq T \end{cases} = f(D,F) \tag{3.5}$$

The higher price of value-added coffee is expected to benefit coffee producers. Price is a major factor that motivates coffee farmers to undertake value addition. Coffee products that have undergone the drying process have higher price standards compared to the fresh coffee cherries. For example, Gonzalez (2007) found that farmers in India receive higher prices for their coffee beans treated with natural-drying or wet-drying process. Furthermore, wet-dry processing producers receive higher portions of the consumer price compared to those producing natural-dried coffee. Susila (2005) also found that the unit price of dried cherries is higher compared to fresh cherries in Indonesia. However, because of the village-level differences in terms of the processing percentage, price differences are significant across villages.

3.3.2 Conceptual Framework

1. Outcome Variable: Value Addition

The study defined value addition as drying and/or shelling coffee. The study hypothesized that the independent variables are statistically insignificant and do not determine the use of value addition. To evaluate this hypothesis, the study determined farm and farmers' characteristics supporting value addition activities. The outcome variables were modeled using the following expression:

$$V = g(X) \tag{3.6}$$

where *V* is as defined, and *X* is a vector of explanatory variables. For the outcome variable, *V*, the option to undertake value addition is specified as the categorical variable in the questionnaire for the conditions of the sold coffee (e.g., fresh cherries, dried cherries, or hulled coffee beans). The study changed the categorical variable into a binary variable coded as 1 if the condition of the sold coffee was dried and/or hulled coffee and 0 if the sold coffee was fresh cherries. The binary variable D, the decision to dry cherries, was coded as 1 if the farmer dried cherries and 0 if they did not. The latent variable H, the choice to hull dried cherries, was valued at 1 if the farmer hulled dried cherries and 0 if they did not.

$$D = g_1(X)$$

$$H = g_2(X)$$

2. Independent Variables

The decision to engage in value addition was influenced by farm and farmer characteristics. Given that Robusta and Arabica coffee production in Uganda is distinctive across different regions, it is important to understand the effect of location on the decision to add value, since location also influenced the type of coffee produced and how much of it was produced.

Independent variables included demographic characteristics (e.g., the head-of-household’s sex, age, and education), farm characteristics (e.g., size of farm and coffee variety), and regions (e.g., place of residence) in the following models.

$$V = g(Demographic; Farm; Region)$$

$$D = g_1(Demographic; Farm; Region)$$

$$H = g_2(Demographic; Farm; Region)$$

For farmer characteristics, this study used schooling year, age, and gender. For farm characteristics, the study used place of residence and land size allocated to coffee. Age of household head has been found to be associated with the post-harvest decision to add or not add value to coffee beans in Ethiopia (Minten et al. 2015). Mathias (2009) conducted a study aiming to determine the explanatory variables influencing the choice to hull coffee based on survey data collected in the Masaka district of Uganda. The study concluded that older coffee farmers produce higher percentages of fresh coffee rather than hulled coffee. Older producers are less likely to adopt new methods in their farms than the younger producers (Mathias 2009).

Gender is also linked to select value addition methods employed in the value chain (Mnimbo et al. 2017). Women and men use different tactics to improve value of their produce. In Tanzania, women are more likely to utilize primary processing on their produce than men, while men tend to increase market participation and use of inputs (Mnimbo et al. 2017). In Ethiopia, women are more associated with undertaking post-harvest processing and participating in extension, whereas men tend to focus on production and sales in the market (Gashaw et al. 2019).

Table 3.6: Summary of the Fitted Variables

Type	**Variables**	**Type of Variable**
	Model 1	
	Dependent Variables	
On-farm processing (drying and/or hulling)	Value addition	Binary (yes/no)
Independent variables		
Demographic characteristics	Age	Continuous
	Gender	Binary (yes/no)
	Schooling year	Continuous
Region	Region	Binary (yes/no)
Farm characteristics	Coffee land size	Continuous
	Arabica grower	Binary (yes/no)
	Robusta grower	Binary (yes/no)
	Model 2	
	Dependent Variables	
Value-added coffee	Dried cherries; Hulled grain	Binary (yes/no)
	Independent Variables	
Demographic characteristics	Age	Continuous
	Gender	Binary (yes/no)
	Schooling year	Continuous
Region	Region	Binary(yes/no)
Farm characteristics	Coffee land size	Continuous
	Arabica grower	Binary (yes/no)
	Robusta grower	Binary (yes/no)

Both total farm size and land size allocated to coffee have been shown to affect the farmer's decision to add value (Mathias 2009). Due to economies of scale, producers with larger farmlands tend to be more likely to add value. This may suggest that value addition is not untaken purely to enhance price but also to defend product quality by preventing loss. Larger farmers, *ceteris paribus*, are not likely to experience higher risks of loss, making the decision to add value more attractive.

Robusta producers can more frequently utilize value addition rather than Arabica growers. Natural drying is relatively easy and inexpensive to undertake at the farm level, though incompletely drying under bare ground causes mold and may result in quality deterioration (World

Bank 2011). On the other hand, while the wet-drying method is usually implemented at wet stations and farm at a relatively high cost due to the specific facility and large amount of water required to complete the process, using the wet method helps maintain high price (You and Bolwig 2003). Given that Arabica is a superior coffee with a higher price, wet methods are generally preferred to further enhance the quality of Arabica (Coffee Stylish 2013). In other words, producing Arabica requires investing in the higher cost of the wet-dry process for higher price rather than the natural-dry method. The natural-dry method is, however, commonly used for Robusta. In fact, the number of wet-mills conducting wet-drying in Uganda is only 22, while the number of dry-mills hulling dried coffee cherries is 537 (UCDA 2019b), Arabica coffee producers seem to have relatively low access to wet stations and prefer to sell fresh coffee rather than adding value to their Arabica coffee. Natural-dried Arabica, which is called *Drugar* (Dry Uganda Arabica), occupies a second position in the quality band of Arabica due its inconsistent quality compared to washed Arabica (Morjaria and Sprott 2018).

Table 3.7: Description of Explanatory Variables Influencing Value Addition

Variables	**Description**	**Significant Literature**	**Hypothesis of Effect on Undertaking Value Addition**
Household head age	Household head age	Minten et al. (2015); Mathias (2009)	(-)
Gender	Gender (male=1; female=0)	Mnimbo et al. (2017); Gashaw et al. (2019); Jeeva (2019)	(-)
Education	Education	Rogers (1995); Musebe et al. (2007); Gashaw et al. (2019)	(+)
Region	Region	Musebe et al. (2007)	(+)/(-)
Farm Size	Coffee land size	Mathias (2009)	(+)
Coffee variety	Robusta; Arabica	World Bank (2011)	(+)/(-)

3. Explanation of variables of farmers' performance

This section examines whether the decision to engage in value addition was associated with the proportion of price received by coffee producers and whether there are statistically significant differences between the prices of value-added coffee by type. In the following section, the study will evaluate the extent to which value addition influenced the price and revenue received by Ugandan coffee farmers and determine whether these amounts differed statistically from fresh cherries prices and across the two value-added products (e.g., dried cherries compared to shelled beans). In other words, the study will consider whether value addition actually improved the price and revenue of the farmers engaging in these practices.

Changes in price due to coffee valuation can be easily identified using data provided by UCDA (2019e). For example, the proportion of the price of coffee received by farmers and processors was clearly different when value addition was undertaken (Table 3.8). While the data was not clear as to the farm gate price of fresh cherries, one can expect it to be lower than the price of dried cherries. When the study examined the price of coffee relative to its level of value addition, it was clear that dried cherries of Robusta accounted for UGX 1,650 and UGX 3,730 of hulled coffee. Green coffee beans were priced 1.25 times higher than dried cherries in the production year of 2013/14. Even in the same valuation phase, the price varied significantly depending on the type of coffee. Arabica had a limited growing area compared to Robusta and was traded at higher price in the international market. Arabica parchment was three times more expensive than Robusta dried cherries and 1.3 times higher than Robusta green beans, which reflects further added value compared to dried cherries.

Table 3.8: Average Price Received by Producers and Processors

Year	Robusta (UGX/kg)		Arabica (UGX/kg)
	Dried Cherries	Hulled Coffee Beans	Parchment
2009/10	1,180	2,390	3,720
2010/11	1,880	3,860	7,450
2011/12	1,840	3,940	5,980
2013/14	1,650	3,740	5,060
2014/15	2,150	4,260	6,120
2015/16	2,210	4,430	5,140
2016/17	2,330	4,990	6,200
2017/18	2,150	4,850	5,620

Source: UCDA 2019e; International Coffee Organization 2019

4. Empirical Model Specification

To determine which if any factors relative to coffee farmers influenced their decision to add value, the study used a logit model for the outcome variable of value addition. Since the study examines the factors influencing the decision between two responses, "adding value" or "not adding value," and therefore estimates the probability of an event using a dependent variable that is not continuous, the logit model was most appropriate. For the choice of the value addition, the binary choice V_i is 1 if the latent variable V_i^* is greater than 0, and V_i is 0 if the latent variable V_i^* is equal or less than 0. The latent variable V_i^* in this study is the expected effect of the value addition although it is unobservable (Cameron and Trivedi 2005). The latent variable, or index function, in this study is a continuous function that provides the index of the unobserved propensity for value addition. The study did not observe this index function since it is a propensity of value addition, instead observing whether or not the household conducted value addition. Accordingly, the study instead used the household's binary choice to either add value or not add value, as demonstrated below:

$$\boldsymbol{V_i = \begin{cases} 1 \ if \ V_i^* > 0 \\ 0 \ if \ V_i^* \leq 0 \end{cases}} \tag{3.7}$$

The probability of value-addition activities *V* is *p* and can be expressed as:

$$V_i = \begin{cases} 1 \; with \; probabilty \; p \\ 0 \; with \; probability \; 1-p \end{cases}$$

The logit model provides the description of the effect of explanatory variables on dependent variables with binary responses (e.g., the response "yes" or "no" to a specific question; Fitzmaurice and Laird 2001). The difference between logit regression and linear regression is that while the logit model uses a discrete property in the dependent variable, linear regression uses dependent variables with continuous values (Fitzmaurice and Laird 2001). If the binary or latent dependent variable $\boldsymbol{V_i}$ is 1 in the case of V_i^*> 0, the probability of the event is p. If the binary dependent variable $\boldsymbol{V_i}$ is 0 in the event of $\boldsymbol{V_i^*} \leq 0$, the probability of the case is $1-p$ (Greene 2003).

Thus, the conditional probability of value addition on coffee is given by:

$$\mathrm{P}(V_i = 1 \mid x_1, \dots, x_k) = \Gamma(x_1, x_2, \dots x_k) \tag{1}$$

Using the probability of engaging in value addition, the logit model is:

$$\Gamma(x_1, x_2, \dots x_k) = \frac{\exp\,(\beta_0 + \beta_1 x_1 + \beta_2, x_2 + , \dots + \beta_k x_k)}{1 + \exp\,(\beta_0 + \beta_1 x_1 + \beta_2, x_2 + , \dots + \beta_k x_k)} \tag{2}$$

$$logit\big(P(V_i = 1 | x_1, \dots, x_k)\big) = \beta_0 + \beta_1 x_1 + \beta_2, x_2 + \cdots + \beta_k x_k \tag{3}$$

where $\Gamma(x_1, x_2, \dots x_k)$ is the logistic cumulative distribution function conditional on the independent variables. The logistic cumulative distribution function alters the regression into interval [0, 1]. The logit regression can be expressed as equation (3) with constant β_0 and coefficients of independent variables $\beta_1, \dots, \beta_k$. Although the logit model has coefficients, the odds ratio is usually used in interpretation of the relative probability of a certain event. Since the study used odds ratios, if the study took a logarithm on the logit model, this would generate the odds ratio. For example:

$$Odds\; ratio_i = \exp\,(\beta_0 + \beta_1 x_1 + \cdots + \beta_k x_k) = \frac{p}{1-p} \tag{4}$$

The odds ratio examines the relative risk of value addition relative to no value addition. The odds ratio is useful when examining the relative probability of adding value and can be explained using the percentage term. For example, if the odds ratio is 1, then the probability of value addition is identical between both groups of those who add value and those who does not, conditional on the covariates x_i. If the odds ratio is 1.5 for a regressor with a continuous variable and if the regressor increases by 1 unit, the probability of adding value increases by 50%, *ceteris paribus*. The independent variables in this study are the head-of-household age, gender, education, size of farm, coffee variety, and place of residence.

5. Research Hypotheses

The study hypothesized that the average price received by farmers adding value was higher than the average price received by farmers not adding value (or selling fresh cherries), regardless of the coffee variety being considered. The study also hypothesized that the more value a farmer added, the higher the price received. This would create a hierarchy of prices with the price of fresh cherries at the bottom and the price of shelled beans at the top.

If the price of shelled beans, the price of dried cherries, and price of fresh cherries are defined respectively as μ_H, μ_D, and μ_F, then the hypotheses may be specified as follows:

$$H0: \mu_D = \mu_F$$

$$H1: \mu_D > \mu_F$$

$$H0: \mu_H = \mu_F$$

$$H1: \mu_H > \mu_F$$

$$H0: \mu_H = \mu_D$$

$$H1: \mu_H > \mu_D$$

Based on the discussion of the independent variables in the model, the study hypothesized that households with more land allocated to coffee and with higher education levels were more likely to add value. Based on the regional distribution of coffee varieties and the fact that processing Arabica is more tedious and costly, the study also hypothesized that farms located in the Central Region of Uganda would be more like to add value than those located in the Northern or Eastern Regions. The study anticipated no difference between coffee farms located in the Western Region and the Northern or Eastern Region in their probability to add value to their coffee at either level of value addition.

$$H_0\colon \beta_L = 1$$

$$H_1\colon \beta_L > 1$$

$$H_0\colon \beta_{CR} = \beta_{WR} = 1$$

$$H_1\colon \beta_{CR} > 1;\ \beta_{WR} > 1$$

$$H_0\colon \beta_E = 1$$

$$H_1\colon \beta_E > 1$$

$$H_0\colon \beta_R = 1;\ \beta_A = 1$$

$$H_1\colon \beta_R > 1;\ \beta_A > 1$$

where β is the respective estimated odds ratios and the subscripts are defined as follows:

L = land size allocated to coffee; CR = Central Region; WR = Western Region; E = Education; R = Robusta coffee; and A = Arabica coffee.

Chapter 4 - Results and Discussion

This section presents the results from the empirical analyses conducted during this study using data from the 2013/14 Uganda National Panel Survey (UNPS), as well as a discussion of the results addressing the study's objectives. The chapter is divided into three sections. Section 4.1 presents summary statistics of the relevant variables. Section 4.2 presents the results of the differences between the prices and revenues of farmers adding or not adding value. Section 4.3 presents the results of the regression analysis. The results discuss the influence of farmer and farm characteristics on the decision to add value.

4.1 Summary Statistics of Data

This study used data collected by the 2013/14 UNPS. The study focused solely on coffee producers and covered a sample size of 489 households. The study will report the summary statistics by coffee variety (e.g., Robusta and Arabica). Table 4.1 shows that 310 households/farmers produced Robusta coffee on an average of 0.21 hectare of land per farmer. Men accounted for about 73% of household heads producing Robusta, and those men had an average age of about 50.2 years. They also spent about 5.4 years on average in school. The average coffee revenues for Robusta farmers were UGX 332,970. The average prices for fresh Robusta fresh cherries, dried cherries and hulled coffee beans were estimated at about UGX 1,600, UGX 3,370 and UGX 3,790, respectively. The average sales of Robusta fresh cherries, dried cherries and hulled coffee beans were 71 kg, 125 kg and 131 kg, respectively. To calculate the total coffee sales, the quantity of dried cherries and hulled coffee beans are converted to the equivalent quantity of fresh cherries. One kilogram of hulled coffee beans is processed from 5.3 kilograms of fresh cherries; one kilogram of dried cherries is processed from 3.2 kilograms of fresh cherries according to Gutierrez et al. (2013). The average total Robusta coffee sold by farmers was estimated at 389 kg on fresh cherry basis. The fresh-basis conversion rates used for estimating the total coffee sold were presented in Table 3.5.

Table 4.1: Summary Statistics of Household Demographics and Farm Characteristics for Robusta Farmers

Variable	*N*	*Mean*	*Std. Dev.*	*Median*	*Min*	*Max*
Head-of-household's age (years)	310	50.2	15.6	50	23	92
Schooling (years)	310	5.5	3.7	6	0	14
Male (1 = yes)	310	0.73			0	1
Size of coffee land (ha)	310	0.21	0.23	0.14	0.01	1.60
Total coffee sales (kg)	246	389	748	196	5	8,874
Fresh coffee cherries sales (kg)	108	71	91	50	5	823
Dried coffee cherries sales (kg)	91	125	180	90	10	1,600
Hulled coffee beans sales (kg)	68	131	196	100	3	1,530
Fresh coffee cherries price (UGX)	108	1,600	1,170	1,000	530	5,460
Dried coffee cherries price (UGX)	91	3,370	1,860	3,000	1,200	8,990
Hulled coffee beans price (UGX)	68	3,790	2,000	3,400	1,300	10,500
Total coffee revenue (UGX)	246	332,970	510,040	153,750	3,000	5,058,000

Source: UNPS 2013/14 and Author's calculations using data from UNPS 2013/14

Table 4.2 also shows that 230 farmers produced Arabica coffee on an average of 0.29 hectare of land per farmer. Men accounted for 69% of Arabica farmers, with an average age of 49 years and an average education of 5.6 years. The average coffee revenues for Arabica farmers were UGX 416,440. The standard deviations for the statistics were very large, suggesting that there was a very large degree of heterogeneity among coffee farmers. The average prices for Arabica fresh cherries, dried cherries and hulled coffee beans were estimated at about UGX 1,960, UGX 3,110, UGX 5,220, respectively. The average sales of Arabica fresh cherries, dried cherries and hulled coffee beans were 117 kg, 238 kg and 165 kg, respectively. The average total Arabica coffee sold by farmers was estimated at 454 kg on fresh cherry basis.

Table 4.2: Summary Statistics of Household Demographics and Farm Characteristics for Arabica Farmers

Variable	*N*	*Mean*	*Std. Dev.*	*Median*	*Min*	*Max*
Head-of-household's age (years)	230	49.0	15.3	46	16	88
Schooling (years)	230	5.6	3.4	6	0	13
Male (1 = yes)	230	0.69			0	1
Size of coffee land (ha)	230	0.29	0.41	0.16	0.01	3.94
Total coffee sales (kg)	173	454	967	115	6	9,600
Fresh coffee cherries sales (kg)	107	117	303	35	6	2,400
Dried coffee cherries sales (kg)	68	238	407	105	5	3,000
Hulled coffee beans sales (kg)	15	165	194	100	10	770
Fresh coffee cherries price (UGX)	107	1,960	1,240	1,600	530	5,330
Dried coffee cherries price (UGX)	68	3,110	2,060	2,380	1,020	8,880
Hulled coffee beans price (UGX)	15	5,220	3,180	4,000	2,200	16,000
Total coffee revenue (UGX)	173	416,440	681,350	152,000	6,000	4,800,000

Source: UNPS 2013/14 and Author's calculations using data from UNPS 2013/14

Table 4.3 shows the results of T-test on land size, production and revenue by coffee variety. It shows that the study cannot reject the null hypothesis that there is no difference between the total coffee sales of Robusta and Arabica and thus the difference is statistically not significant ($|t| < 2$). The dissertation rejects the null hypothesis and conclude that the sizes coffee land between Arabica and Robusta are statistically different ($|t| > 2$). Fresh cherries sales of Robusta are statistically the same as those of Arabica ($|t| < 2$). The null hypothesis tested the difference between Robusta and Arabica dried cherries sales, and the dissertation conclude that they are statistically different ($|t| > 2$). The result shows that the there is no difference between the hulled beans sales of Robusta and Arabica and thus the difference is statistically not significant, and the study fails to reject the null hypothesis ($|t| < 2$). The dissertation cannot reject the null hypothesis that there is no difference between the total sales revenue of Robusta and Arabica, and conclude they are not statistically different ($|t| < 2$). As Table 4.3 shows, the number of farmers selling Robusta dried coffee cherries and Arabica dried coffee cherries are 91 and 68, respectively. Even though the average dried cherries sales for Arabica is greater than Robusta and the difference is statistically significant, the number of farmers selling dried coffee cherries sales of Robusta is greater by 33 % than Arabica. The number of farmers selling hulled coffee beans of Robusta and Arabica are 68 and 15, respectively. The number of farmers selling hulled coffee beans of Robusta is over four times greater than Arabica. The average hulled coffee beans sales of Arabica is marginally higher than Robusta, but the difference is statistically not significant. The result shows that the average size of land for Arabica production is greater by 38 % than Robusta ($p < 0.007$), and the dried coffee cherries sales of Arabica is higher by 90 % than Robusta ($p < 0.019$).

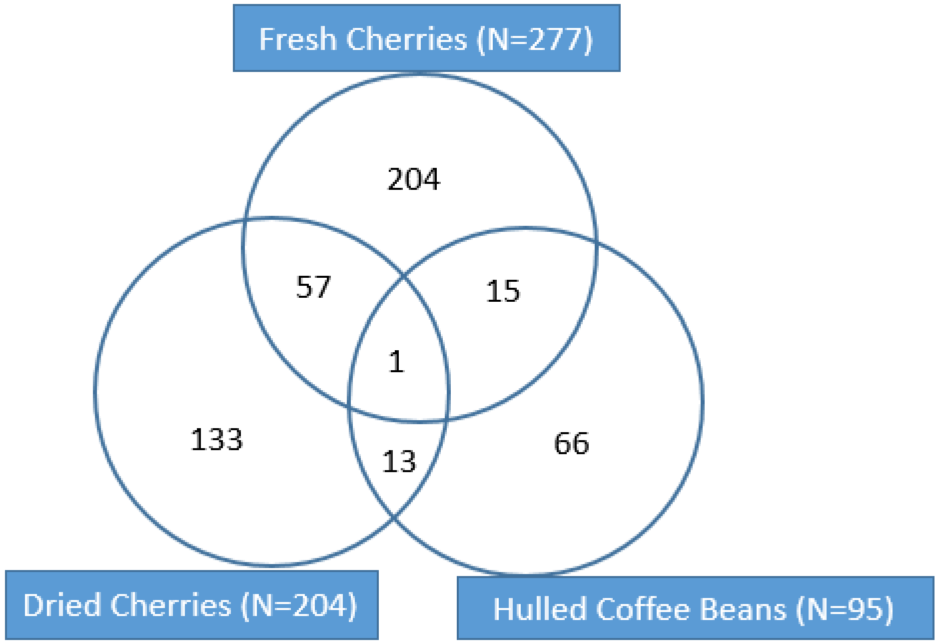
Table 4.3: Results of T-test on Land size, Production and Revenue by Coffee Variety

	Robusta			Arabica			Probability	Sig-nifi-cance
	N	Mean	SD	N	Mean	SD		
Size of coffee land (ha)	310	0.21	0.23	230	0.29	0.41	t =-2.692, p-value =0.007	***
Total coffee sales (kg)	246	389	748	173	454	967	t = 0.779, p-value =0.436	
Fresh coffee cherries sales (kg)	108	71	91	107	117	303	t = -1.497, p-value=0.135	
Dried coffee cherries sales (kg)	91	125	180	68	238	407	t = -2.363, p-value=0.019	**
Hulled coffee beans sales (kg)	68	131	196	15	165	194	t = -0.614, p-value=0.540	
Total coffee revenue (UGX)	246	332,970	510,040	173	416,440	681,353	t= -1.433, p-value =0.152	

Source: UNPS 2013/14 and Author's calculations using data from UNPS 2013/14
**** = 1%, ** = 5%, * = 10%*

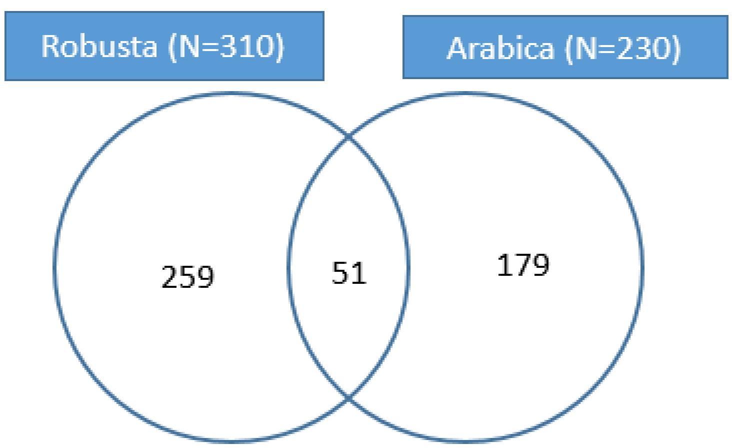
As Figure 4.1 demonstrates, among 489 coffee producers, the number of producers selling fresh cherries was 277, accounting for 71% of total farmers, while the number of farmers producing dried cherries was 204, or 53%, and the number of farmers producing hulled coffee beans was 95, or 24%. Some farmers produced multiple types of coffee (e.g., producing both fresh and dried cherries or dried cherries and hulled beans). The number of farmers who produced both fresh and dried cherries was 58, while the number of farmers who produced both dried cherries and hulled coffee beans was 14. Finally, the number of farmers who produced both fresh cherries and hulled beans was 16. There was one farmer who sold fresh cherries, dried cherries, and hulled beans. As Figure 4.1 presents, the number of Robusta producers was 259, accounting for 63% of total farmers. The number of Arabica farmers was 230, accounting for 47% of total farmers. Additionally, 51 farmers produced both Robusta and Arabica, 208 farmers produced only Robusta, and 128 farmers produced only Arabica.

Figure 4.1: Number of Farmers by Value Addition (N = 489)



Source: Author's calculations using data from UNPS 2013/14

Figure 4.2: Number of Farmers by Variety (N = 489)



Source: Author's calculations using data from UNPS 2013/14

4.2 Results of Price Difference by Value-Added Coffee

As Table 4.1 and Table 4.2 demonstrate, the prices for each product level increased with the level of value addition across both coffee varieties. The study hypothesized that for value addition to make sense economically, the price and revenue accrued from dried cherries must be higher than the price and revenue of fresh cherries and thus statistically significant. Likewise, the difference between dried cherries and shelled coffee prices and revenues must be positive and statistically significant. This should be true for both coffee varieties.

To test whether the difference in price was statistically significant, the study used two sample T-tests. The test calculated the difference between two variables and tested three hypotheses to determine whether there existed a difference between two variables and which variable was greater than the other. The study rejected the null hypothesis that there were no price differences between dried cherries and fresh cherries. According to Table 4.4, the price of dried Robusta coffee cherries was UGX 1,770 higher than fresh cherries and thus statistically significant ($p < 0.000$). On the other hand, as Table 4.5 shows, the difference between the prices of shelled Robusta coffee beans and dry Robusta cherries was UGX 420 and only statistically significant ($p < 0.089$).

Table 4.4: Results of T-test on the Price of Robusta Dried and Fresh Cherries

	H_0: Dried − Fresh = 0					
Robusta	*N*	*Mean*	*Std. Err.*	*Std. Dev.*	*95% Conf. Interval*	
Price of Dried Cherries	91	3,370	190	1,860	2,980	3,760
Price of Fresh Cherries	108	1,600	110	1,170	1,380	1,820
Combined	199	2,410	120	1,760	2,160	2,660
Difference		1,770	220	-	1,340	2,200
H_1: Difference < 0	Prob (T < t) = 1.000					
H_1: Difference ≠ 0	Prob (T ≠ t) = 0.000					
H_1: Difference > 0	Prob (T > t) = 0.000					
Degree of Freedom	197	t-value	8.169			

Source: Author's calculations using data from UNPS 2013/14

Table 4.5: Results of T-test on the Price of Robusta Dried Cherries and Hulled Beans

	H_0: Dried − Hulled = 0					
Robusta	*N*	*Mean*	*Std. Err.*	*Std. Dev.*	*95% Conf. Interval*	
Price of Dried Cherries	91	3,370	190	1,860	2,980	3,760
Price of Hulled Beans	68	3,790	240	2,000	3,300	4,270
Combined	159	3,550	150	1,920	3,250	3,850
Difference		-420	310	-	-1,020	190
H_1: Difference < 0	Prob (T < t) = 0.089					
H_1: Difference ≠ 0	Prob (T ≠ t) = 0.178					
H_1: Difference > 0	Prob (T > t) = 0.911					
Degree of Freedom	157	t-value	-1.353			

Source: Author's calculations using data from UNPS 2013/14

According to Table 4.6, the price difference between dried and fresh Arabica cherries was estimated at UGX 1,150 and found to be statistically significant ($p < 0.000$). Finally, the price difference between Arabica dried cherries and hulled Arabica beans was UGX 2,110, and the study therefore rejected the null hypothesis that there was no difference between the price of dried cherries and hulled coffee beans ($p < 0.001$). The price of hulled coffee was higher compared to dried coffee (Table 4.7). The result of the T-test shows that the difference in price was statistically significant. There existed a price difference between value-added coffee and coffee that has either not had value added or has had less value added. The price of dried cherries was higher than the price of fresh cherries. Likewise, the price of hulled coffee beans was greater than of dried cherries.

Table 4.6: Results of T-test on the Price of Dried and Fresh Arabica Cherries

	H_0: Dried $-$ Fresh $= 0$					
Arabica	N	Mean	Std. Err.	Std. Dev.	95% Conf. Interval	
Price of Dried Cherries	68	3,110	250	2,060	2,610	3,600
Price of Fresh Cherries	107	1,960	120	1,240	1,720	2,190
Combined	175	2,400	130	1,700	2,150	2,660
Difference		1,150	250	-	660	1,640
H_1: Difference < 0	Prob (T < t) = 1.000					
H_1: Difference ≠ 0	Prob (T ≠ t) = 0.000					
H_1: Difference > 0	Prob (T > t) = 0.000					
Degree of Freedom	173	t-value	4.614			

Source: Author's calculations using data from UNPS 2013/14

Table 4.7: Results of T-test on the Price of Dried and Hulled Arabica Coffee

	H_0: Dried $-$ Hulled $= 0$					
Arabica	N	Mean	Std. Err.	Std. Dev.	95% Conf. Interval	
Price of Dried Cherries	68	3,110	250	2,060	2,610	3,600
Price of Hulled Beans	15	5,220	820	3,180	3,460	6,980
Combined	83	3,490	270	2,420	2,960	4,010
Difference		-2,110	650	-	-3,410	-810
H_1: Difference < 0	Prob (T < t) = 0.001					
H_1: Difference ≠ 0	Prob (T ≠ t) = 0.002					
H_1: Difference > 0	Prob (T > t) = 0.991					
Degree of Freedom	81	t-value	-3.233			

Source: Author's calculations using data from UNPS 2013/14

The percentage change of the price of Robusta from fresh cherries to dried cherries was 111%. On the other hand, the percentage change of the price of Arabica from fresh cherries to dried cherries was 59% (Table 4.8). The percentage changes of the prices of Robusta and Arabica from dried cherries to hulled beans were 12% and 68%, respectively. This study shows that Robusta growers tended to add value at a higher rate than Arabica growers, and that they secured a higher percentage of increase in their prices from their value addition activities.

Table 4.8: Percentage Change in Price by Value Addition

	Robusta		**Arabica**	
	Price (UGX/kg)	*Percentage Change*	*Price (UGX/kg)*	*Percentage Change*
Fresh Cherries	1,600	-	1,960	-
Dried Cherries	3,370	111%	3,110	59%
Hulled Beans	3,790	12%	5,220	68%

Source: Author's calculations using data from UNPS 2013/14

4.3 Results of Logit Regression

This study examined the determinants of farmers producing fresh coffee cherries. Using the logit model, the study estimated the effects of household and farm characteristics on households' fresh coffee production without value addition. The results indicate that coffee farm size, schooling years, residence in the Western Region, and growing Robusta grower were all variables that had effects on a farmer's choice to produce fresh coffee cherries. Since the Northern Region has only four data observations, the study combined the Eastern and Northern Regions into a single group.

The dissertation also explored the extent to which these factors influenced whether or not farmers engaged in value addition activities such as drying and/or hulling coffee cherries. The study found that coffee farm size, schooling year, residence in the Central Region, residence in the Western Region, and growing Robusta coffee were variables that influenced the farmer's probability of undertaking value addition (Table 4.9). For example, an increase in one hectare of land increased the odds ratio of value addition by 6.9 times ($p < 0.000$), *ceteris paribus*. Holding all other variables constant, being located in the Central Region increased the odds of value addition by 2.8 times higher ($p < 0.000$) compared to those not adding value and living in the Northern/Eastern Region. The odds of value addition for farmers living in the Western Region increased by 2.4 times compared to those not adding value and living in the Eastern/Northern Region ($p < 0.005$). The odds adding value increased by 14% when the farmer's education increased by one more year (p < 0.000). Being a Robusta grower increased the odds of value addition by 5.6 times (p < 0.000).

Table 4.9: Results of Logit Model on Value Addition (N = 489)

Value Addition	Odds Ratio	Std. Err.	z	P>z	[95% Confidence Interval]	
					LB	UB
Land in Coffee	6.877***	3.464	3.830	0.000	2.562	18.455
Region (Base = Northern + Eastern)						
Central	2.828***	0.835	3.520	0.000	1.586	5.043
Western	2.371***	0.733	2.790	0.005	1.293	4.346
Age	1.010	0.007	1.330	0.185	0.995	1.024
Male	0.975	0.235	-0.110	0.916	0.608	1.564
Schooling (years)	1.135***	0.037	3.930	0.000	1.066	1.209
Arabica	1.482	0.609	0.960	0.339	0.662	3.316
Robusta	5.574***	2.256	4.240	0.000	2.521	12.323
Intercept	0.040	0.027	-4.790	0.000	0.011	0.150
LR chi2(8)	87.22		Prob > chi2	0.000	Pseudo R2	0.131

Source: UNPS 2013/14
**** = 1%, ** = 5%, * = 10%*

The Marginal Effect at Mean (MEM) shows how the probability of output variable changes if a regressor increases by 1 unit while holding all other variables at their means. The MEM results for the estimated logit regression shows that the probability of undertaking value addition increased by 46% when land allocated to coffee increased by one hectare (p < 0.000). Likewise, the probability of undertaking value addition increased by 25% when farmers resided in the Central Region were compared with those in the Eastern/Northern Region and by 21% if farmers resided in the Western Region. The dissertation also found that the probability of adding value increased by 3% with each additional year of education undertaken by the head-of-household, while growing Robusta instead of any other coffee increased the probability of adding value by 41% (p < 0.000). These findings are summarized in Table 4.10.

Table 4.10: Marginal Effects at Mean on Value Addition (N = 489)

Value addition	Marginal effects	Std. Err.	z	P>z	[95% Confidence Interval]	
					LB	UB
Land in Coffee	0.459***	0.118	3.890	0.000	0.228	0.691
Region (Base = Northern + Eastern)						
Central	0.252***	0.070	3.610	0.000	0.115	0.388
Western	0.212***	0.074	2.860	0.004	0.067	0.357
Schooling (years)	0.030***	0.008	3.940	0.000	0.015	0.045
Robusta	0.409***	0.096	4.270	0.000	0.221	0.597

Source: UNPS 2013/14
**** = 1%, ** = 5%, * = 10%*

The Average Marginal Effect (AME) is a different method of calculating margins with MEM. After the marginal effect is estimated for each respondent with their observed level of covariates, then the value becomes averaged. MEM evaluates marginal effects at the mean of each covariate. Unlike MEM, AME is interpreted using percentage points. According to Table 4.11, The probability of undertaking value addition was 39 percentage points higher when land allocated to coffee increased by one hectare ($p < 0.000$). The likelihood of value addition was 2.6 percentage points higher if the number schooling year increased ($p < 0.000$), while the probability of adding value was 35 percentage points higher for Robusta growers than non-Robusta growers ($p < 0.000$). The probability of value addition in the Central and Western Regions was 21 percentage points higher than if located in the Central Region. Additionally, the probability of value addition was 18 percentage points higher if located in the Western Region as opposed to the Northern/Eastern Region. The results of the MEM and the AME look similar, although the magnitude of the AME is relatively small compared to the MEM.

Table 4.11: Average Marginal Effects on Value Addition (N = 489)

Value addition	Marginal effects	Std. Err.	z	P>z	[95% Confidence Interval]	
					LB	UB
Land in Coffee	0.391***	0.097	4.030	0.000	0.201	0.582
Region (Base = Northern + Eastern)						
Central	0.212***	0.057	3.700	0.000	0.100	0.324
Western	0.177***	0.061	2.890	0.004	0.057	0.297
Schooling (years)	0.026***	0.006	4.180	0.000	0.014	0.038
Robusta	0.349***	0.069	5.090	0.000	0.215	0.484

Source: UNPS 2013/14
**** = 1%, ** = 5%, * = 10%*

This study also explored the extent to which the factors influencing value addition as a binary choice explained the undertaking of specific value addition activities (e.g., drying and shelling). The study found that coffee farm size, schooling year, head-of-household's age, residence in the Central Region, and growing Robusta coffee were all variables that influenced the probability of undertaking dried cherries value addition. An increase in one hectare of land increased the odds ratio of drying fresh cherries by 2.4 times compared to not drying ($p < 0.020$), *ceteris paribus*. The odds of drying coffee increased by 6% when the farmer's education increased by one additional year ($p < 0.056$). This suggests that education does not have as compelling an impact on the odds of drying fresh cherries as land does. Furthermore, being located in the Central Region increased the odds of drying fresh cherries by 6.41 times ($p < 0.000$) compared to the odds of not drying fresh cherries and living in the Northern/Eastern Region, holding all other variables constant. Finally, being a Robusta grower increased the odds of drying fresh cherries by 2.9 times ($p < 0.002$) more than a non-Robusta grower. These results are summarized in Table 4.12.

Table 4.12: Results of Logit Regression on Drying Fresh Coffee Cherries (N = 489)

Dried Cherries	Odds Ratio	Std. Err.	z	P>z	[95% Conf. Interval]	
					LB	UB
Land in Coffee	2.407**	0.908	2.330	0.020	1.150	5.041
Schooling (years)	1.062*	0.033	1.910	0.056	0.998	1.129
Age	1.012*	0.007	1.680	0.093	0.998	1.026
Male	1.258	0.306	0.950	0.344	0.782	2.025
Region (Base = Northern + Eastern)						
Central	6.417***	1.996	5.980	0.000	3.489	11.806
Western	1.699	0.559	1.610	0.108	0.891	3.239
Robusta	2.966***	1.055	3.060	0.002	1.477	5.958
Arabica	1.723	0.610	1.540	0.124	0.861	3.449
Intercept	0.025***	0.016	-5.640	0.000	0.007	0.091
LR chi2(8)	83.13		Prob > chi2	0.000	Pseudo R2	0.125

Source: UNPS 2013/14
***** =1%, ** = 5%, * = 10%*

The study examined the extent to which farm and farmer characteristics influenced a farmer's decision to shell dried cherries. The dissertation found that farm size, number of years in school, location of farm, and growing Robusta coffee were all variables which affected the probability of shelling cherries. The results show that an increase of one hectare increased the odds of shelling cherries increased by 2.9 times (p < 0.007), *ceteris paribus*. The odds of shelling cherries increased by 10% over the odds of not shelling when the farmer's education increased by one more year (p < 0.023). Being located in the Central Region decreased the odds of shelling cherries by 83% (p < 0.000) compared to the odds of not shelling and living in the Northern/Eastern Region, holding all other variables constant. The odds of shelling cherries increased 2.4 times for farmers living in the Western Region compared to the odds of not shelling and living in the Northern/Eastern Region (p < 0.008). Being a Robusta grower increased the odds of hulling cherries by 8.9 times (p < 0.000). These results are summarized in Table 4.13.

Table 4.13: Results of Logit Regression on Hulling Coffee Beans (N = 489)

Hulled Beans	Odds Ratio	Std. Err.	z	P>z	[95% Conf. Interval]	
					LB	UB
Land in Coffee	2.868***	1.113	2.710	0.007	1.340	6.137
Schooling (years)	1.093**	0.043	2.270	0.023	1.012	1.180
Age	0.995	0.009	-0.520	0.604	0.977	1.014
Male	0.789	0.257	-0.730	0.466	0.416	1.494
Region (Base = Northern + Eastern)						
Central	0.174***	0.072	-4.230	0.000	0.077	0.391
Western	2.377***	0.780	2.640	0.008	1.250	4.521
Robusta	8.893***	4.531	4.290	0.000	3.276	24.142
Arabica	1.157	0.483	0.350	0.727	0.510	2.623
Intercept	0.036***	0.028	-4.190	0.000	0.007	0.169
LR chi2(8)	117.49		Prob > chi2	0.000	Pseudo R2	0.244

Source: UNPS 2013/14
**** = 1%, ** = 5%, * = 10%*

The MEM results for the estimated logit regression show that the probability of drying cherries increased by 21% when land allocated to coffee increased by one hectare ($p < 0.020$), holding all other variables at their means. Likewise, the probability of drying cherries increased by 41% when farmers resided in the Central Region compared to those in the Eastern/Northern Region, and the probability of drying cherries was 9.5% higher for those in the Western Region compared to the those in the Eastern/Northern Region. The study also found that the probability of drying cherries increased by 1% with each additional year of education undertaken by the head-of-household, while being a Robusta grower increased the probability of drying coffee cherries by 25% ($p < 0.000$). This information is summarized in Table 4.14.

The results of the AME show that the probability of drying cherries increased by 18 percentage points with each additional hectare increase to land allocated to coffee ($p < 0.018$). The likelihood of drying cherries was 1.2 percentage points higher when number of schooling years increased by 1 ($p < 0.053$), while the probability of dried cherry value addition was 21 percentage points higher for Robusta growers compared to non-Robusta growers ($p < 0.001$). The probability of drying cherries was 40 percentage points higher for those residing in the Central Region ($p < 0.000$) and 9.3 percentage points higher for those residing in the Western Region ($p < 0.053$) when compared to those residing in the Northern/Eastern Region (Table 4.15).

Table 4.14: Marginal Effects at Mean on Drying Fresh Coffee Cherries (N = 489)

Dried Cherries	Marginal effects	Std. Err.	z	P>z	[95% Confidence Interval]	
					LB	UB
Land in Coffee	0.212**	0.091	2.320	0.020	0.033	0.390
Region (Base = Northern + Eastern)						
Central	0.412***	0.056	7.390	0.000	0.303	0.521
Western	0.095*	0.057	1.660	0.096	-0.017	0.208
Age	0.003*	0.002	1.680	0.093	0.000	0.006
Schooling (Years)	0.014*	0.008	1.910	0.056	0.000	0.029
Robusta	0.249***	0.075	3.290	0.001	0.101	0.396

Source: UNPS 2013/14
**** = 1%, ** = 5%, * = 10%*

Table 4.15: Average Marginal Effects on Drying Fresh Coffee Cherries (N = 489)

Dried Cherries	Marginal effects	Std. Err.	z	P>z	[95% Confidence Interval]	
					LB	UB
Land in Coffee	0.179**	0.075	2.380	0.018	0.031	0.327
Region (Base = Northern + Eastern)						
Central	0.391***	0.054	7.300	0.000	0.286	0.496
Western	0.093*	0.056	1.650	0.098	-0.017	0.203
Schooling (years)	0.012*	0.006	1.940	0.053	0.000	0.025
Robusta	0.207***	0.060	3.470	0.001	0.090	0.324

Source: UNPS 2013/14
**** = 1%, ** = 5%, * = 10%*

The MEM results for the estimated logit regression shows that the probability of hulling coffee beans increased by 10% when land allocated to coffee increased by one hectare ($p < 0.007$), holding all other variables at their means. Likewise, the probability of hulling coffee beans decreased by 14% when farmers were located in the Central Region compared to those in the Eastern/Northern Region ($p < 0.001$), and it increased by 16% when farmers were located in the

Western Region compared to those in the Eastern/Northern Region ($p < 0.006$). The study also found that the probability of hulling coffee beans increased by 1% with each additional year of education undertaken by the head-of-household, while growing Robusta increased the probability of drying coffee cherries by 18% ($p < 0.000$). These results are summarized in Table 4.16.

Table 4.16: Marginal Effects at Mean of Variables on Hulling Cherries (N = 489)

Hulled Beans	Marginal effects	Std. Err.	z	P>z	[95% Confidence Interval]	
					LB	UB
Land in Coffee	0.100***	0.037	2.710	0.007	0.028	0.172
Region (Base = Northern + Eastern)						
Central	-0.140***	0.040	-3.460	0.001	-0.219	-0.061
Western	0.160***	0.058	2.780	0.006	0.047	0.274
Schooling (Years)	0.008**	0.004	2.230	0.026	0.001	0.016
Robusta	0.180***	0.039	4.630	0.000	0.104	0.257

Source: UNPS 2013/14
**** = 1%, ** = 5%, * = 10%*

The results of the AME show that the probability of hulling cherries was 13 percentage points higher when land allocated to coffee increased by one hectare ($p < 0.005$). The average marginal effect of schooling on production of hulled coffee was 1.1 percentage points if the head-of-household's number of schooling years increased by 1 ($p < 0.021$), while the marginal effect of Robusta growers was 21 percentage points higher than non-Robusta growers ($p < 0.000$). The likelihood of hulling cherries decreased 17 percentage points when the farmer was located in the Central Region compared to the Northern/Eastern Region ($p < 0.000$), being located in the Western Region but increased 15 percentage points compared to the Northern/Eastern Region ($p < 0.005$). These results are summarized in Table 4.17.

Table 4.17: Average Marginal Effects on Hulling Cherries (N = 489)

Hulled Beans	Marginal effects	Std. Err.	z	P>z	[95% Confidence Interval]	
					LB	UB
Land in Coffee	0.126***	0.045	2.790	0.005	0.037	0.214
Region (Base = Northern + Eastern)						
Central	-0.168***	0.040	-4.180	0.000	-0.246	-0.089
Western	0.151***	0.055	2.780	0.005	0.045	0.258
Schooling (Years)	0.011**	0.005	2.320	0.021	0.002	0.020
Robusta	0.213***	0.038	5.690	0.000	0.140	0.287

Source: UNPS 2013/14
**** = 1%, ** = 5%, * = 10%*

Overall, one hectare increases in land allocated to coffee increased the probability of drying or hulling coffee beans. Farmers residing in the Central Region were more likely to produce dried beans rather than hulled or fresh beans. However, farmers residing in the Western Region were more likely to dry or hull coffee. Being a Robusta coffee producer made farmers more likely to add value by drying and hulling coffee. However, the results show that being an Arabica grower was not associated with undertaking value addition. Lastly, additional schooling years undertaken by the head-of-household influenced farmers to undertake value additions of both drying and hulling, although the size of effect of this variable was small.

To test the model specification, the study used the link test. The link test is used to test model specifications in single equation regressions, such as logit analyses. The link test generates the variable of prediction (hat) and the variable of squared prediction (hat squared) and tests the model using these two variables as dependent variables of the model if the model is properly specified. If the model specification is correct, the result shows that the prediction is significant and the squared prediction is not significant. Since the predictor is significant (p <0.000) and squared predictor is insignificant, Table 4.18 demonstrates that this study's model is well specified. The study tested model specification for the three models using the link test. In all tests, the predictor (hat) was significant and the squared predictor was not significant. Thus, the study concluded that the model specification was correct across all three models ($p < 0.000$).

The dissertation also tested multicollinearity to check whether an independent variable was correlated with the other predictors, because the existence of multicollinearity weakens the statistical significance of explanatory variables. In this study, the variance inflation factor (VIF) test was used in Stata to test multicollinearity. The results show that the mean of the VIF was 1.88. Since the value of the VIF was less than 10, the degree of collinearity between independent variables in the model was acceptable.

Table 4.18: Results of Link Test

Value Addition						
	Coef.	Std. Err.	z	P>z	[95% Conf.Interval]	
					LB	UB
Hat	1.086***	0.145	7.470	0.000	0.801	1.371
Hat squared	-0.091	0.072	-1.270	0.206	-0.231	0.050
Intercept	0.047	0.111	0.420	0.672	-0.171	0.265
LR chi2(2)	88.28		Prob > chi2	0.000	Pseudo R2	0.1329
Drying Fresh Cherries						
					[95% Conf.Interval]	
	Coef.	Std. Err.	z	P>z	LB	UB
Hat	1.009***	0.141	7.150	0.000	0.732	1.285
Hat squared	0.015	0.126	0.120	0.905	-0.232	0.263
Intercept	-0.009	0.131	-0.070	0.944	-0.266	0.247
LR chi2(2)	83.14		Prob > chi2	0.000	Pseudo R2	0.125
Hulling Cherries						
					[95% Conf.Interval]	
	Coef.	Std. Err.	z	P>z	LB	UB
Hat	1.007***	0.237	4.250	0.000	0.543	1.471
Hat squared	0.002	0.074	0.030	0.973	-0.142	0.147
Intercept	0.001	0.176	0.010	0.994	-0.343	0.346
LR chi2(2)	117.49		Prob > chi2	0.000	Pseudo R2	0.244

Chapter 5 - Summary, Conclusions, and Recommendations

5.1 Implications

Coffee is the primary income source of half a million farmers in Uganda (United Nations 2017). However, the yield of coffee has become stagnant during the last three decades even though other coffee producers have experienced remarkable improvement in coffee production during the same period. The government of Uganda has developed incentives to increase coffee production, such as supplying seedlings to coffee farms.

The research problem of this study was concerned with value addition as a possible means to increase producers' shares of market prices. The producers would extract a certain share of the value that those downstream buyers would otherwise receive commensurate to activities undertaken to create value. The benefits of value addition have not been appropriately assessed for Ugandan farmers as a strategic policy initiative. Understanding the competitive benefits of value addition would offer possibilities to support larger volumes of coffee production as well as higher qualities of coffee, which in turn would improve Uganda's position in the global coffee industry.

To address this problem, this study posed two research questions, considering (1) what farm and farmer characteristics supported value addition activities, and (2) to what extent value addition activities enhanced coffee farmers' realized prices. The first objective of this study was to describe the characteristics of Uganda coffee farmers and compare farm and farmers' characteristics of those adding value to those who are not. The study evaluated the extent to which value addition influenced the performance of Ugandan coffee farmers in order to provide insight for policymakers seeking to ensure the achievement of the National Coffee Policy.

The study used odds ratio in logit models to estimate the effects of variables on the probability of value addition. The results of the study show that growing Robusta coffee, land allocated to coffee, number of years in school, and location of farm were all variables that influenced farmers' probability of drying and/or hulling coffee cherries. Being a Robusta grower increased the odds of value addition by 5.6 times ($p < 0.000$) compared to not adding value, *ceteris paribus*. The results of the MEM show that growing Robusta instead of any other coffee varieties increased the probability of adding value by 41% ($p < 0.000$), holding all other variables at their means. An increase in one hectare of land increased the odds of value addition by 6.9 times ($p < 0.000$). The result of the MEM also shows that the probability of undertaking value addition increased by 46% when land allocated to coffee increased by one hectare. An additional year of schooling undertaken by the head-of-household also increased the probability of drying and/or shelling cherries, but the size of the effect was small. Based on the results, this study achieved its objectives to describe the characteristics of Uganda coffee farmers and compare farm and farmers' characteristics of those adding value to those not.

Based on the summary statistics, the average coffee prices per kilogram of fresh cherries, dried cherries, and hulled beans of Robusta were UGX 1,600; UGX 3,370; and UGX 3,790, respectively. The average prices of fresh cherries, dried cherries, and hulled beans of Arabica were UGX 1,960; UGX 3,110; and UGX 5,220, respectively. The study used two sample T-tests to determine the difference in prices between two variables. The results show that the price of Robusta dried cherries was UGX 1,770 greater than that of fresh cherries ($p < 0.000$). The results also show that the price of Robusta hulled beans was UGX 420 greater than that of dried cherries ($p < 0.090$). For Arabica, the price of dried cherries was UGX 1,150 greater than that of fresh cherries ($p < 0.000$). The price of hulled beans was UGX 2,110 higher than that of dried cherries ($p < 0.001$). As this demonstrates, the size of difference in price differed depending on the coffee variety. The size of difference in price for Robusta between dried cherries and fresh cherries was greater than that of

Arabica. On the other hand, the difference in price for Arabica between hulled coffee beans and dried cherries was greater than that of Robusta.

The main result of the study is that Robusta was the second important determinant influence of the probability of adding value. This may be because drying or hulling Robusta coffee is easier than drying or hulling Arabica. According to the literature, more than 60% of coffee's quality is decided during the post-harvest processes of drying and hulling. For this reason, characteristics of the coffee such as taste and aroma are sensitive to the drying method and its environments.

There are two primary methods of drying and shelling cherries: the natural-dry (sun-dry) method and the wet-dry method. Most Robusta coffee in Uganda is dried using the natural-dry method, while 40% of Arabica is dried using the wet-dry method due to the high demand for wet-dried Arabica in the global market. The natural-dry method is relatively inexpensive, requires less labor than wet-dry processing, and carries a lower risk of quality degradation during processing (UCDA 2008; de Melo Pereira et al. 2014). Natural drying seems relatively simple; fresh cherries are dried under the sun until the moisture content of the cherry beans become 12%. After drying, farmers remove the coffee cherries' outer layers manually.

On the other hand, the wet-dry method has more steps, including pulping, washing, sorting, and drying. Because the step of washing involves the fermentation process, skilled labor and technology are required to prevent the coffee from deteriorating. The number of wet processors in Uganda is low, though farmers can use hand pulpers, which allow them to remove the cherries' flesh and skin at their farms. Since wet-dry processing requires skilled labor and technology to produce high-quality coffee, Arabica producers may sell it as fresh cherries rather than undertaking value addition in order to avoid price reduction due to quality degradation during wet drying.

Although the study cannot calculate the costs of drying and hulling, since the data the study used did not provide accurate costs for production, the literature provides evidence that the wet-dry methods are two times more expensive than sun-dry methods (UCDA 2008; USAID 2010; UCDA 2019a). For these reasons, Robusta growers may have easily added value, while Arabica growers might have hesitated to undertake value-added activities. There also exist farmers who produced both Robusta and Arabica and who produced more than two types of coffee (e.g., producing both fresh and dried cherries or dried cherries and hulled coffee beans), although the number of farmers producing different value-added forms of coffee or growing both varieties were relatively minor in the data.

Land allocated to coffee is a proxy of production size. Based on the results of the study, land size was related to the decision of value addition. It is possible that when coffee land size increased, the farm was more likely to adopt innovative practices than smallholders (Feder 1980; Boahene 1999). There were obvious price differences between dried cherries and hulled beans, or fresh cherries and dried cherries in the results, showing that the higher prices of value-added coffee in larger volumes of coffee production may have motivated farmers to increase their farm income by undertaking value addition. Greater production would be an incentive to add value that, in turn, would lead to a higher income for the farmer. On the other hand, those who produced less had smaller incomes compared to those who produced more, so the increased change in sales revenue due to the higher prices of value-added coffee would be lesser. Therefore, coffee farmers with smaller land size may have had fewer incentives to engage in value addition than those who held greater land sizes allocated to coffee production.

The results of the study show that education had a positive impact on coffee value addition. More educated farmers tended to adopt improved practices on their produce (Musebe 2007), which allowed them to avoid quality deterioration and produce higher quality value-added coffee, which was expected to bring higher price premiums. Although the sun-drying process is said to be easier than the wet-drying process, farmers utilizing the former must possess knowledge regarding the sequence of drying at the right time, gathering cherries on rainy or humid days, and finishing the drying to the proper moisture content. The educated farmers would have appropriately conducted the dry processing in a timely manner.

The results of study also show that the location of producers in the Central Region and the Western Region influenced the probability of value addition. According to the results of the odds ratio in the logit regression on drying fresh cherries, for every year a producer aged, their odds of drying cherries increased by 1% ($p < 0.093$). A possible explanation for this is that older farmers may have had more experience in coffee production and undertaking value addition activities. Although the effect of farmer's age was significant, its effect size was close to zero.

5.2 Conclusions

Coffee is one of the main agricultural exports and foreign exchange earners for Uganda. There are 1.7 million coffee farmers in Uganda, and coffee is the main income source for half a million households. The literature shows that when farmers add value to their commodities, they can enhance their share of the final market price of their commodities. There has been increasing interest in helping farmers add value to their commodities. Whether this actually enhances their economic performance is not yet clear for coffee growers in Uganda. Therefore, the primary objective of this dissertation was to test whether value addition does indeed improve coffee farmers' performance in Uganda.

Coffee farmers can add value by drying coffee cherries and/or shelling their cherries. There are two major coffee varieties produced in Uganda: Robusta and Arabica. While some farmers produce only a single variety, others produce both varieties despite their unique agronomic requirements. The dissertation explored the value addition initiatives by farmers who produced only Robusta, only Arabica, and those who produced both varieties. The study attempted to describe the characteristics of Ugandan coffee farmers and compare the characteristics of farms and farmers adding value to those not adding value. The study also evaluated the extent to which value addition influences the performance of Ugandan coffee farmers in an attempt to provide insight for policymakers to ensure the achievement of the National Coffee Policy.

This study used odds ratios in logit models to estimate the effects of variables on the probability of value addition. To assess the performance of coffee famers, two sample T-tests were used to check the price difference between value-added and non-value-added coffee. The results indicate that the main determinant influencing the decision to add value was coffee land size. The next most important determinant was being a Robusta grower. It is possible that these results are due to the fact that value addition activities for Robusta are much easier and more feasible for farmers than those for Arabica. Most Robusta is dried using natural-dry processing, and less than half of Arabica is dried using the wet-dry method, which carries a relatively higher risk of quality degradation if skilled labor and equipment are not input. The results indicate that coffee land size also deeply influences the value-added activities. This may be because as more land is allocated to coffee, coffee production increases. The increased coffee production may become an incentive to add value in order to improve sales income, since the price of dried cherries is obviously higher than that of fresh cherries, and the price of hulled coffee beans is clearly greater than that of dried cherries. The expected higher revenue would motivate farmers to add value. The result of the T-test indicates that the more value was added, the higher market price received by Robusta and

Arabica producers, except in the difference between Robusta dried cherries and hulled coffee beans.

Given the importance of value addition to the performance of coffee producers and considering that Robusta growers and greater coffee land sizes positively affect value addition on coffee, the dissertation would suggest policymakers invest resources in distributing Robusta seedlings, which allow farmers to undertake value addition more easily than Arabica. In addition, given that most small farmers have limited land, high-yield seedlings, replanting, and proper husbandry practices will be required to increase production and farm incomes.

5.3 Recommendations for Policy and Future Research

The results of this study reflect that policymakers should support seedling initiatives on the Robusta variety to develop incentives for Uganda coffee producers. It should be pointed out that coffee producers can make value addition easier, and that the drying and/or hulling process is related to the coffee sales of farmers. Instead of encouraging Arabica production simply because of its high market price, the policy recommendation based on the results of this study would be to distribute Robusta seedlings to increase Robusta production and recognize that value addition on Robusta is easier for producers than value addition on Arabica. Given that most of Uganda's topography is suitable for Robusta, further policy support should be maintained for Robusta production.

The results further show that coffee land size is the key influential explanatory variable on the drying and/or hulling decision. Increases in land allocated to coffee increases coffee production, and policies aimed at increasing the average coffee farm size would increase value addition opportunities and contribute to better performance. This may be accomplished through encouraging farmers to consolidate their holdings through organizing strategic alliances, which would help them diversify their operations and specialize their operations to improve their labor and management productivity. Accelerating and expanding the high-yield seedling distribution program alongside these strategic alliances among farmers to consolidate operations would enhance the sustainability of the program. Regardless of increasing producer specialization through strategic alliances, acceleration and expansion of the high-yield seedling distribution could be supported with helping farmers improve their intensification strategies to get the most out of their landholdings. Of course, these initiatives would all come with improved husbandry efforts, such as use of better nutrient use and care for trees, as well as post-harvest management.

Coffee value addition should be focused on producing high quality coffee, as 60% of coffee quality is determined by post-harvest operations (Hameed et al. 2018) and coffee quality is linked to coffee price premium (Musebe et al. 2007). Training sessions to make farmers understand proper drying and hulling methods are required to avoid quality deterioration during the drying and/or hulling processes. Strategic policy initiatives could be developed along these lines to increase sustainable coffee production and help achieve the government of Uganda’s objective of reaching 20 million bags by 2030.

This study used secondary data from the 2013/14 UNPS. Using secondary data presents some important limitations. Because the survey and questionnaire were designed for specific purposes that are different from the questions posed for this research, there may be possible differences in the interpretation of certain variables from the original definition intended by the designer to the definition used in this study. Being aware of this risk, the study has taken care to explain as clearly as possible where differences in meaning may exist. The data presents an imprecise cost structure of coffee production and value addition, and the study was not able to examine the effect of value addition on household farm profits. The study calculated the price received by coffee farmers using sales revenues and quantities sold to assess the farmers' performances.

This study was not able to assess profitability of coffee producers due to imprecise costs provided by the secondary data. The suggestion for further research is to use primary data collected with information regarding production, post-harvest, marketing costs, and estimations of the profitability of producers by variety and type of dry-method (e.g., natural-dried Robusta, natural-dried Arabica, and wet-dried Arabica). Natural-dried Arabica accounts for 60% of Arabica in Uganda, and its demand is increasing in the Asian market. Despite the importance of natural-dried Arabica to Ugandan coffee, it has not been explored in the literature. The dissertation suggest that future studies evaluate the extent to which value addition influences the profitability of coffee farm by coffee variety. Finally, the study recommends future researchers estimate variation of price elasticity by different types of value addition. Doing so would support farmers' understanding of the production of value-added coffee depending on price change.

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